Renewable Energy Efforts in California

Opportunities for Renewable Integration in Technology & Infrastructure

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California Tribal Training
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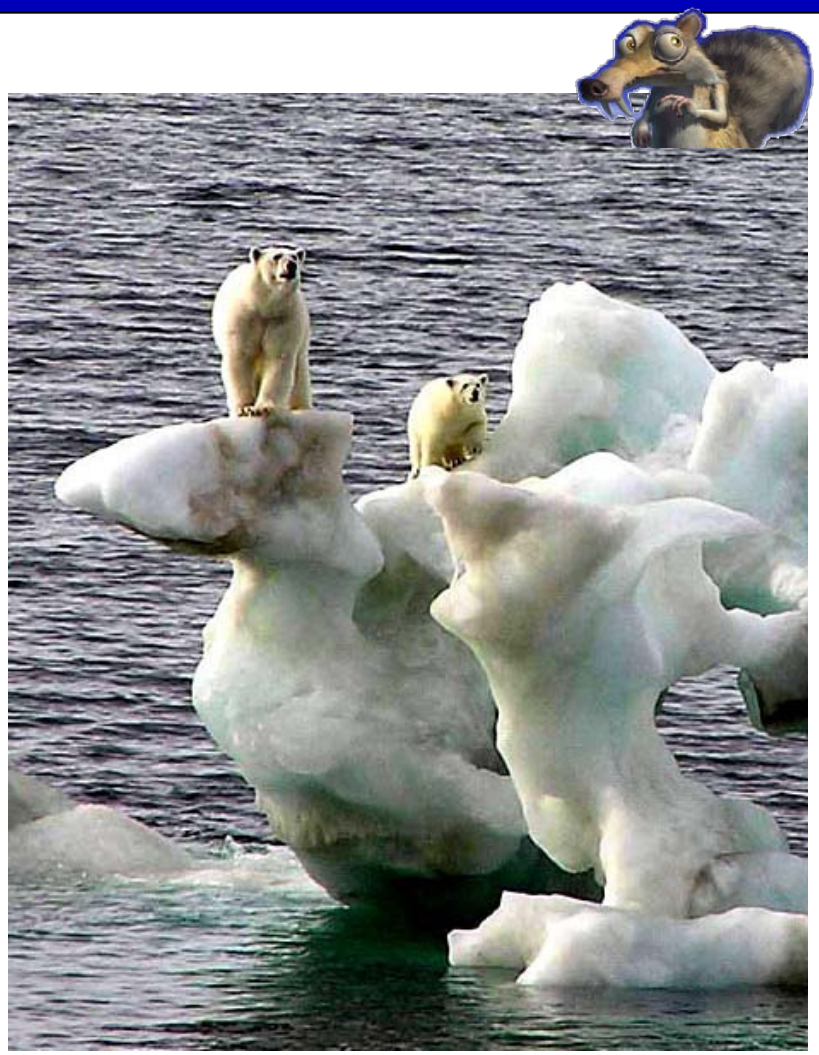
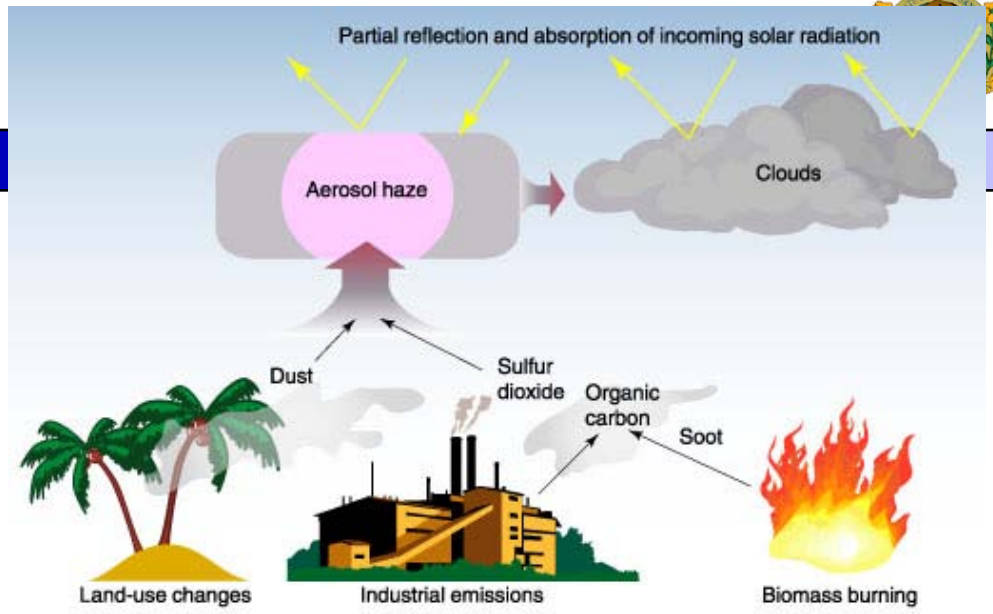
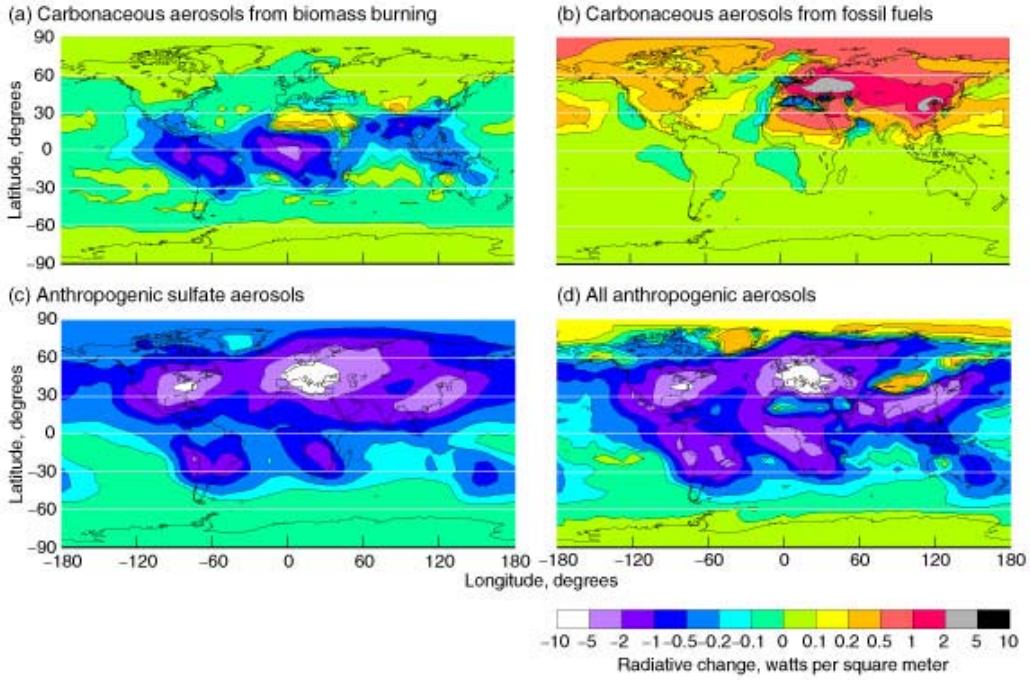
RENEWABLE ENERGY PROGRAM
CALIFORNIA ENERGY COMMISSION

PIER
PUBLIC INTEREST ENERGY RESEARCH
"Research Powers the Future"

Global Warming



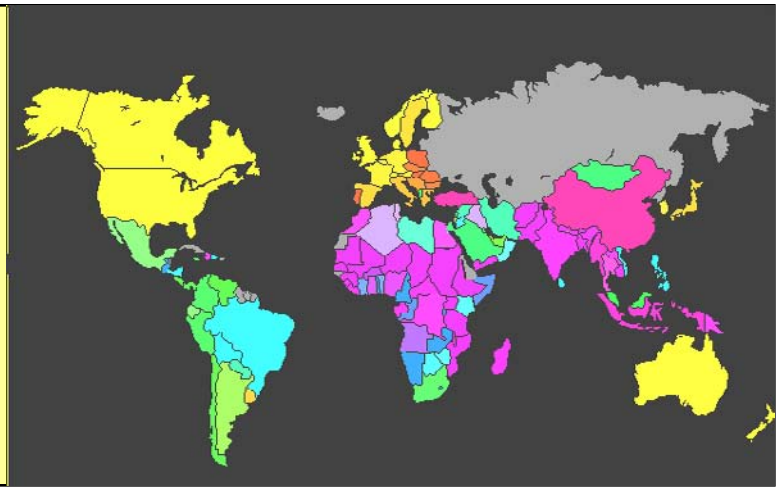




Is it really us?

World Perspective – We're not alone!

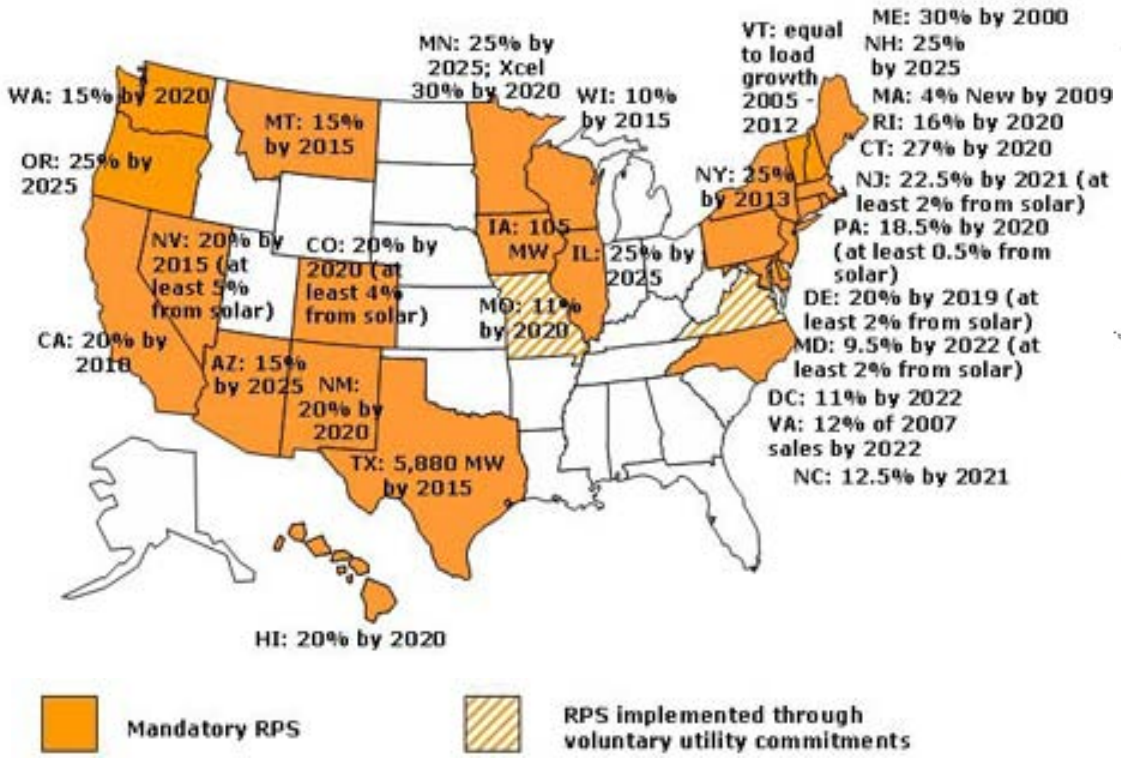
Governments throughout the world are focusing energy policy strategy to address the following goals:

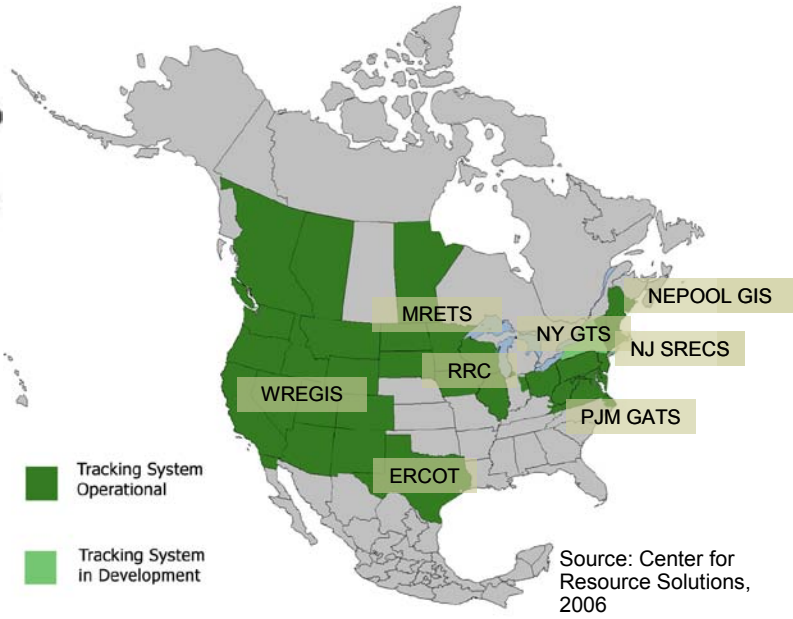


- Reduce and mitigate climate change impacts (pollution, GHG)
- Strengthen energy security by reducing dependence on oil
- Eliminate fuel poverty by diversifying with environmentally-friendly resources
- Support economic growth & competitiveness

RPS Nationwide

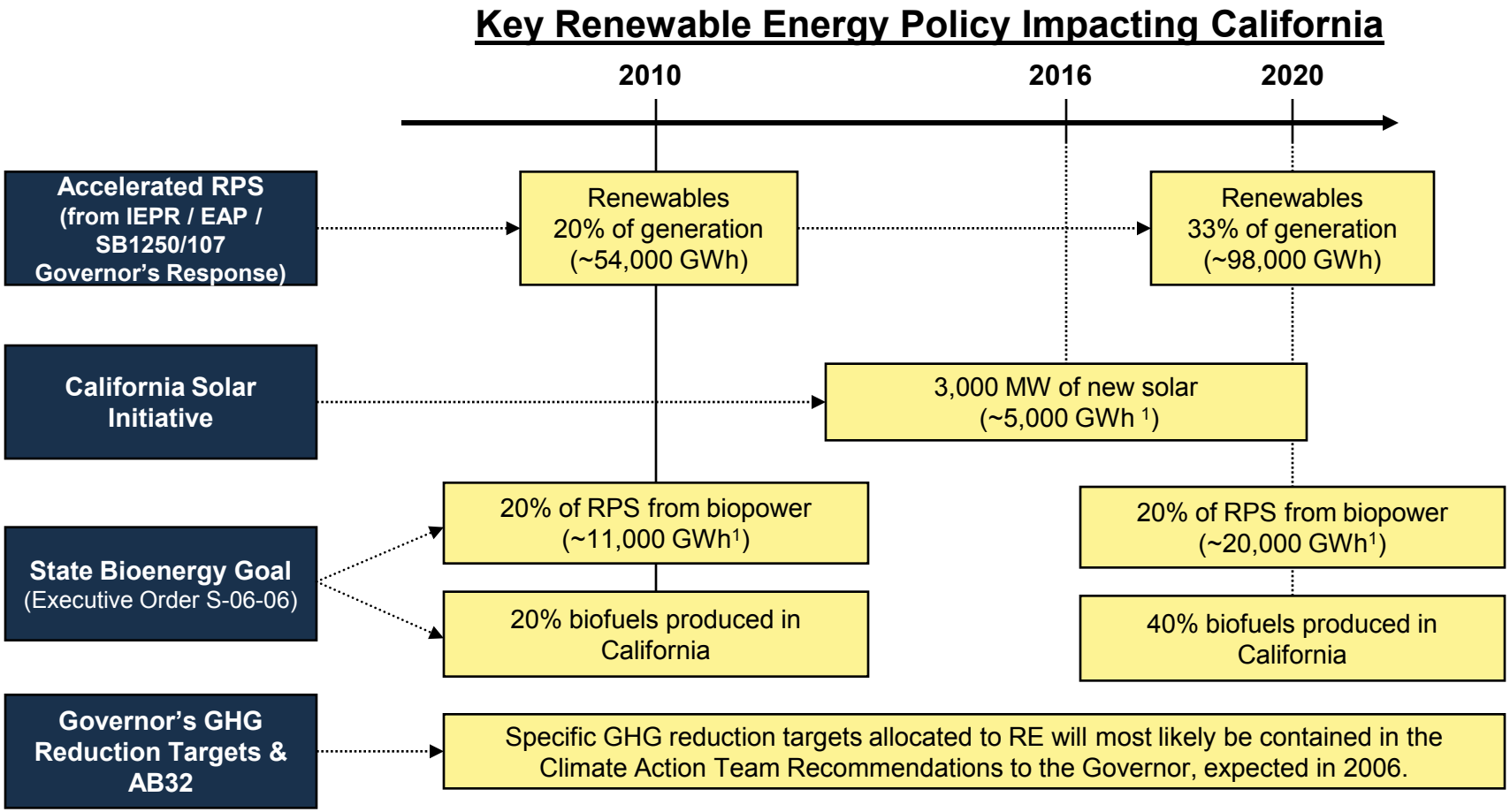
- 26+ states have mandatory RPS (portfolios mix of resources) & tracking
- Mainland states are addressing new renewable integration challenges
- Mainland states are interconnected regionally and share control authority
- Mainland states are members of NERC and share in the integration planning efforts





Attribute Tracking System for RPS - WREGIS

Key CA Renewable Energy Policies



1. Assumed average capacity factors are 20% for solar and 90% for biopower.
Note: The roadmap also considered detailed policy guidance as stated in the IEPR.

A Critical Question

How do we integrate a large amount of renewable energy sources into our way of life (onto the grid) without sacrificing reliability?

Facts of Life:

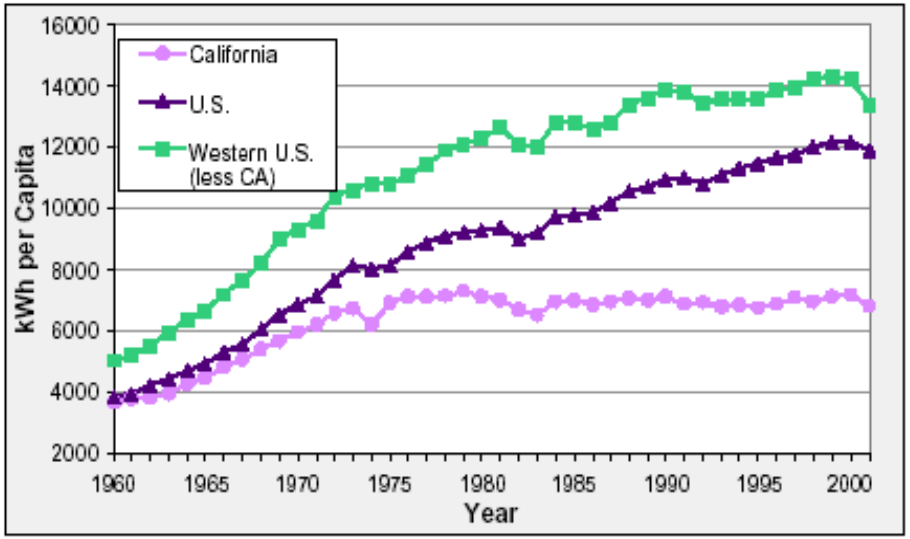
- **Mandated Renewable Portfolio Standard (wind, geothermal, biomass, etc)**
- **Wind, geothermal, biomass…resources have different generation characteristics**
- **Current power systems were not designed to operate with large amounts of differing and variable renewable resources**
- **When ANY resource is not carefully integrated (planned) onto the power system, the system will be more prone to failures**

Overview

- RPS Policies and Roles in Perspective
- Challenges for CA to Integrate Renewables
- Putting it all Together – Integrated Planning
  - Near-term research efforts & options
  - Long-term sustainable future
  - Continuing efforts
- Points to Share

Background: Renewable Energy in California

- For decades, California led the country and the world in renewable energy procurement and energy efficiency standards
- From its peak in early 1990s, renewable generation declined amid market uncertainties
- In 1996, AB 1890 placed surcharge on electricity sold by IOUs to be used to fund public interest programs, including renewable energy

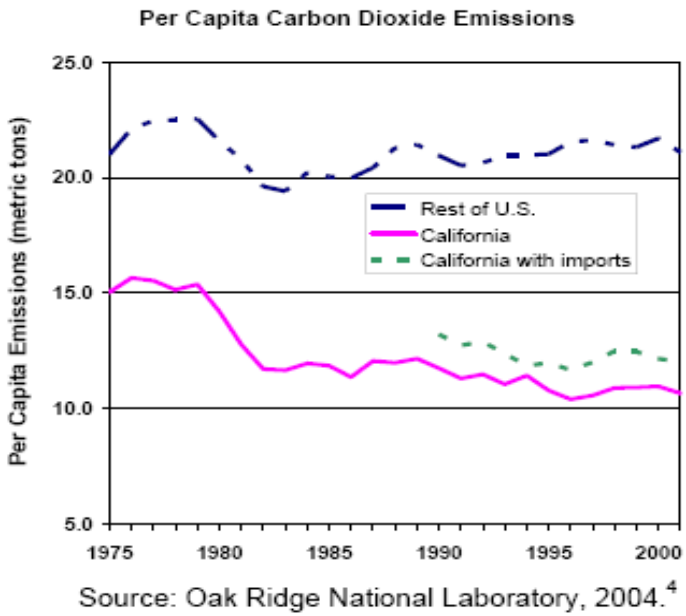


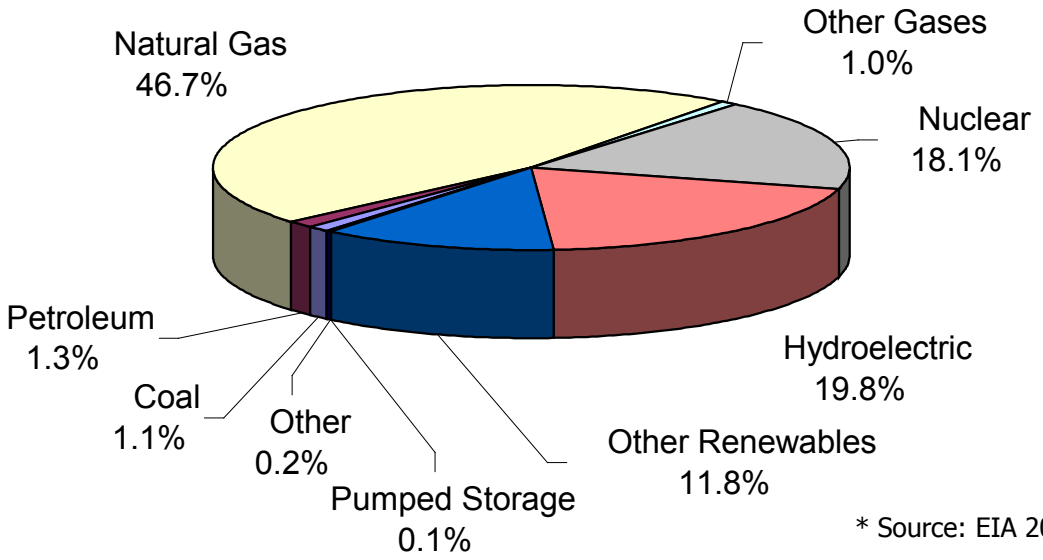
Californians use almost 50% less electricity than the U.S. average
Source: Energy Information Agency and California Energy Commission

- Creation of California Energy Commission Programs
  - Public Interest Energy Research (PIER), a program to support and conduct energy research, development and demonstration (RD&D) projects that will help improve the quality of life in California by bringing environmentally safe, affordable and reliable energy services and products to the marketplace (http://www.energy.ca.gov/pier/)
  - Renewable Energy Program, a subsidy mechanism to support renewable development in a market environment (http://www.energy.ca.gov/renewables/)
- 2002 Enactment of a statewide Renewable Portfolio Standard (RPS) to increase diversity, reliability, public health and environmental benefits of California's energy mix.

Today's California Energy Picture

- Diverse mix of renewable and conventional generation
- Top 10 generation plants are gas, nuclear and hydro resources
- Lead in energy efficiency and ranks 3rd in petroleum refining capacity
- Primary resource is natural gas, 80% imported from other states & Canada
- Nearly 25% of electricity consumed is imported from neighboring states over high voltage DC lines

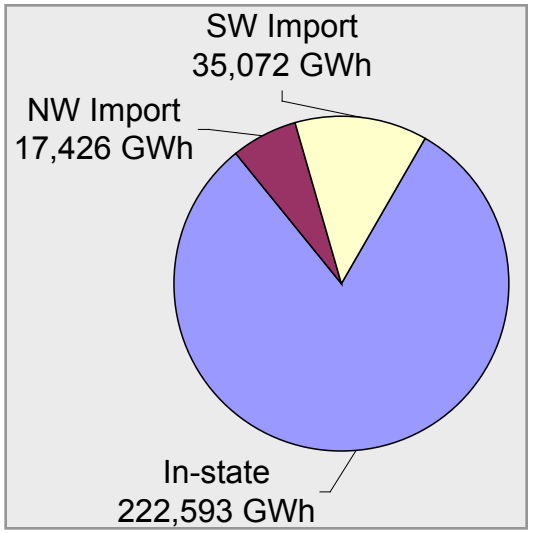


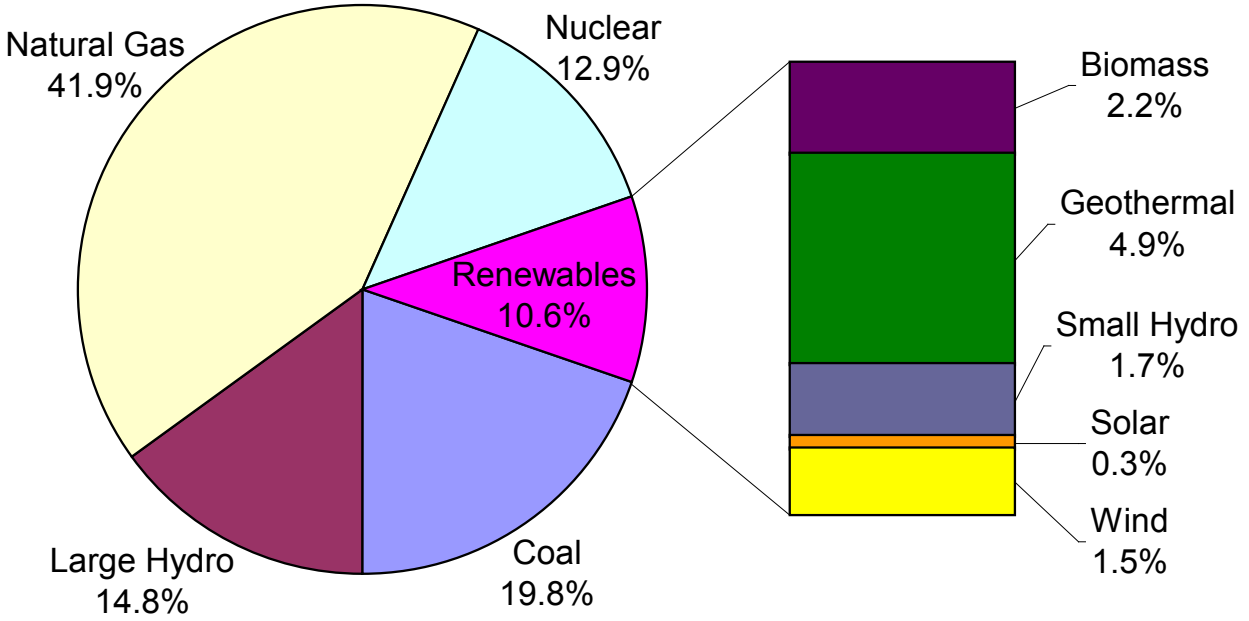


* Source: EIA 2005

California Electricity

Total Gross System Energy 275,091 GWh





Most diverse portfolio of electrical generating resources

2004 Gross System Energy Source: CEC

RPS Eligible Technologies

- Biomass
- Biodiesel
- Conduit hydro
- Fuel cells using renewable fuel
- Digester gas
- Geothermal
- Landfill gas
- Municipal solid waste conversion
- Ocean wave, ocean thermal, tidal current
- Photovoltaic
- Small hydro
- Solar thermal electric
- Wind

IOU RPS Contracts by Technology

	PG&E	SCE	SDG&E	Total
Wind	531	2,019 – 2,387	357	2,907 – 3,275
Biogas	9 – 99	8 – 9	24	41 – 132
Biomass	105 – 125	44 – 69	84	232 – 277
Geothermal	435 – 570	335 – 545	20	790 – 1,135
Ocean	2	0	0	2
Small Hydropower	1	0	5	6
Solar Thermal	731	500 – 850	399 – 999	1,629 – 2,579
Solar Photovoltaic	7	8 – 22	0	15 – 29
TOTAL (MW)	**1,820 – 2,065**	**2,914 – 3,882**	**887 – 1,487**	**5,622 – 7,434**

Source: California Energy Commission, Database of IOU Contracts for Renewable Generation, January 14, 2008, update, www.energy.ca.gov/portfolio/IOU_CONTRACT_DATABASE.XLS. Totals may not sum due to rounding.

Roles and Collaborations

CEC ROLE

- Certify renewable facilities as eligible for the RPS.
- Design and implement accounting system to track and verify RPS compliance.
- Distribute Supplemental Energy Payments (SB 1036 deletes CEC authority to award SEPs and transfers administrative responsibility to CPUC)

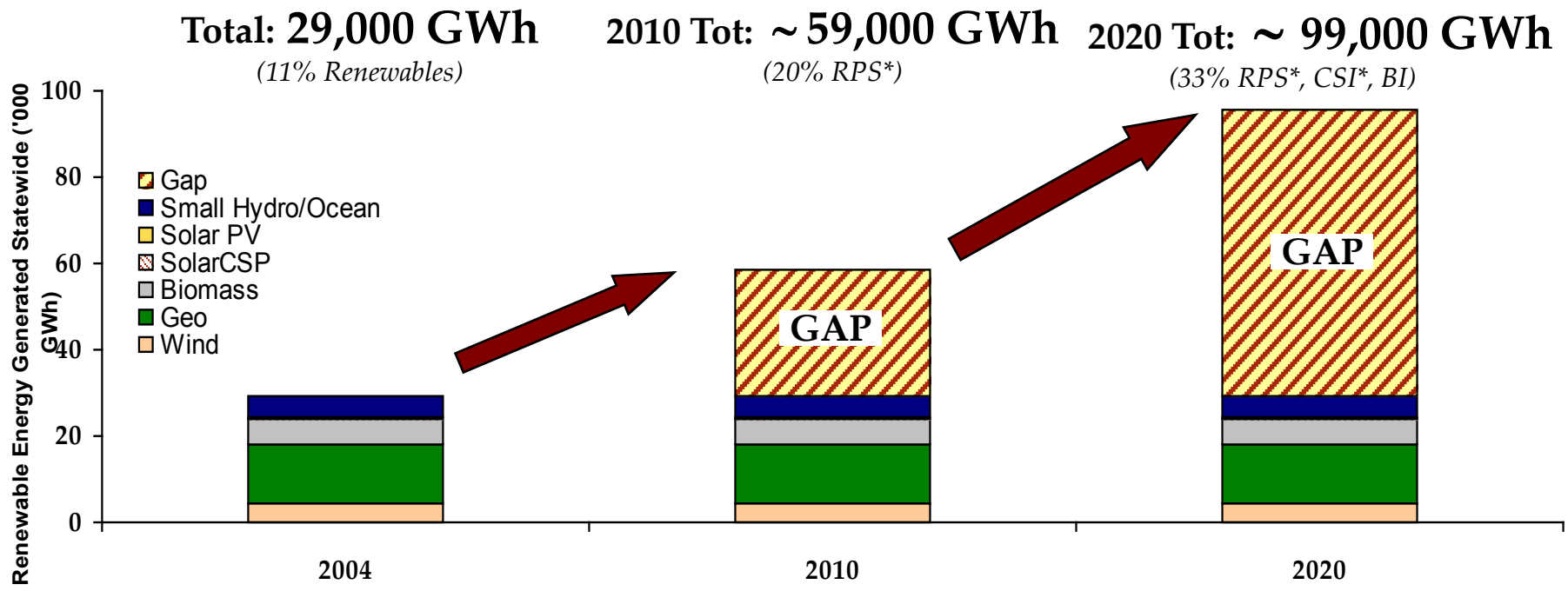
CPUC ROLE

- Oversight of IOU procurement:
  - Approve procurement plans.
  - Set baselines and targets.
  - Develop market price referent.
  - Develop least-cost-best-fit process to evaluate bids.
  - Set rules for flexible compliance.
  - Standardize contract terms.
  - Approve/ reject contracts.
  - Ensure RPS competitiveness.
- Oversight for other “retail sellers.”

Roles of Others ?

California RPS Projections

Projected Renewables to Meet California Policy Goals



Data Sources: 2004, CEC Electricity Report which includes all renewables in the State, not just IOUs; 2010 and 2020, PIER Renewables Projections.

*RPS: Renewable Portfolio Standard; EAP Accelerated goal of 33% by 2020
*CSI: California Solar Initiative

Integration Challenges

- Constrained and insufficient transmission and distribution (T&D) infrastructure
- Limited peak generating capacity and flexible units
- Lack of operating experience at high renewable penetration levels
- Abundant in-state renewable resources and aggressive policy for growth, but lacking a “game plan” (RPS) to help prioritize development
- Lack of integrated system
- Coordinated planning of resources outside of CA
- Aging infrastructure!!!

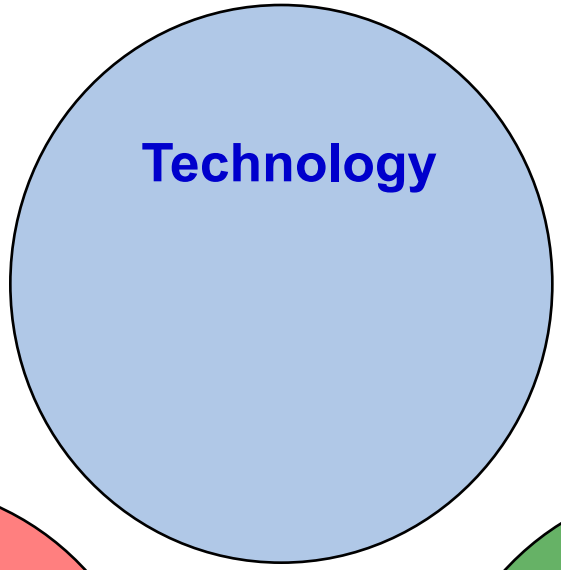
*Source: EIA

Renewable Integration Questions

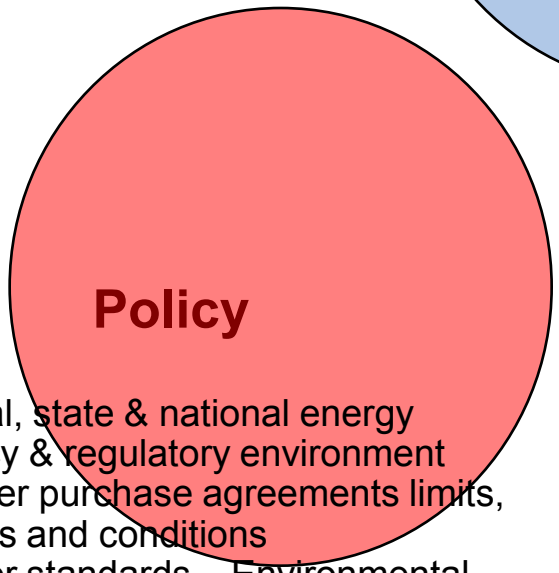
- What will the future electricity system look like and where will renewable resources likely to come from – remote locations, distributed locations, out-of-state?
- What is needed for the grid to accommodate renewables (technologies/infrastructure, market, regulation)?
- What are the impacts of increasing renewable energy penetration on system reliability and dispatchability?
- Will the “planned” system last another 30-40 years?

How do you pull it all together?

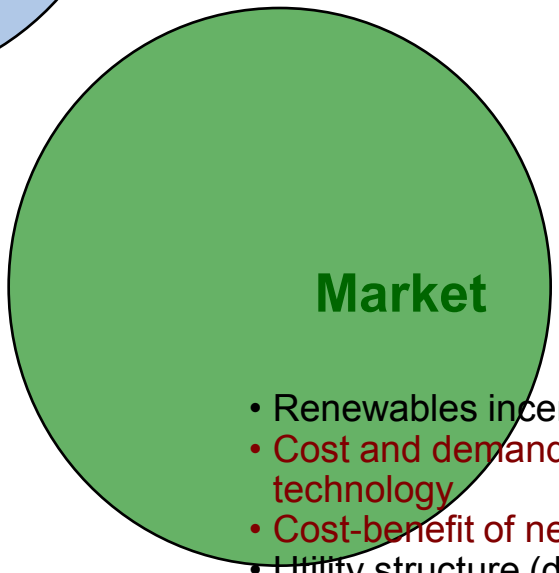
Three Pulls – Technology, Market, Policy/Regulatory



- Characterize renewable resources
- Limitations of transmission infrastructure
- Mix of generation resources
- Age and lifespan of existing technology
- Understanding of new technology
- Fit of new technology to existing infrastructure and location



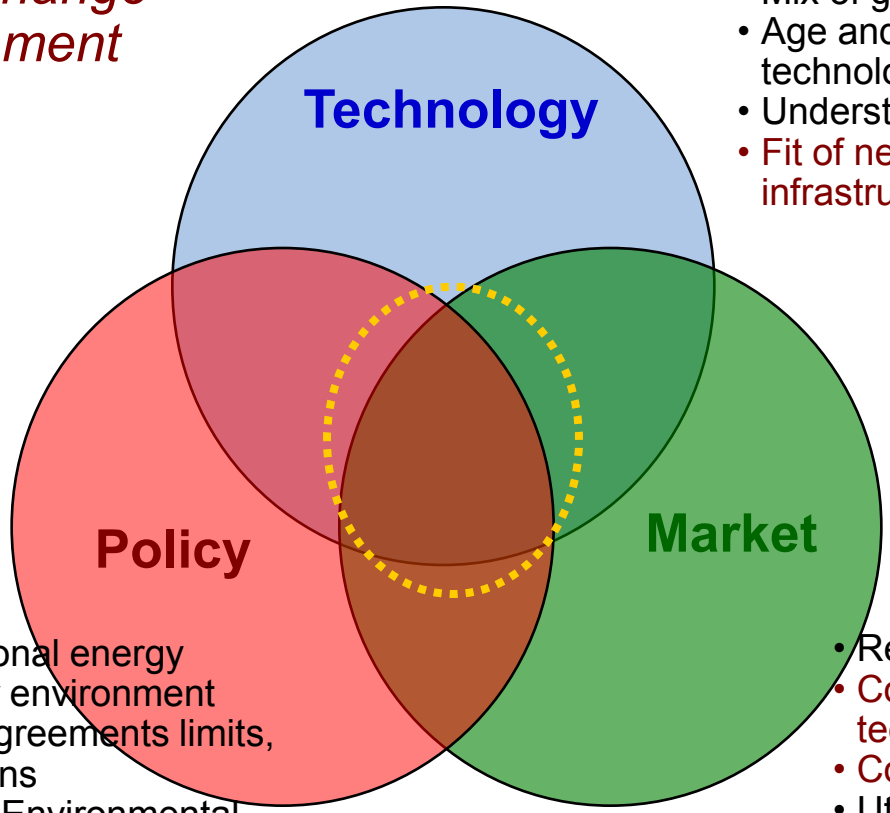
- Local, state & national energy policy & regulatory environment
- Power purchase agreements limits, terms and conditions
- Other standards – Environmental, air quality, energy efficiency
- National and other sovereign nation's policy



- Renewables incentives
- Cost and demand for new technology
- Cost-benefit of new technology
- Utility structure (deregulated or vertical)
- Green energy service credit for renewables

Three Pulls – Technology, Market, Policy/Regulatory

Convergence of the 3 Pulls often signifies a "change" conducive environment



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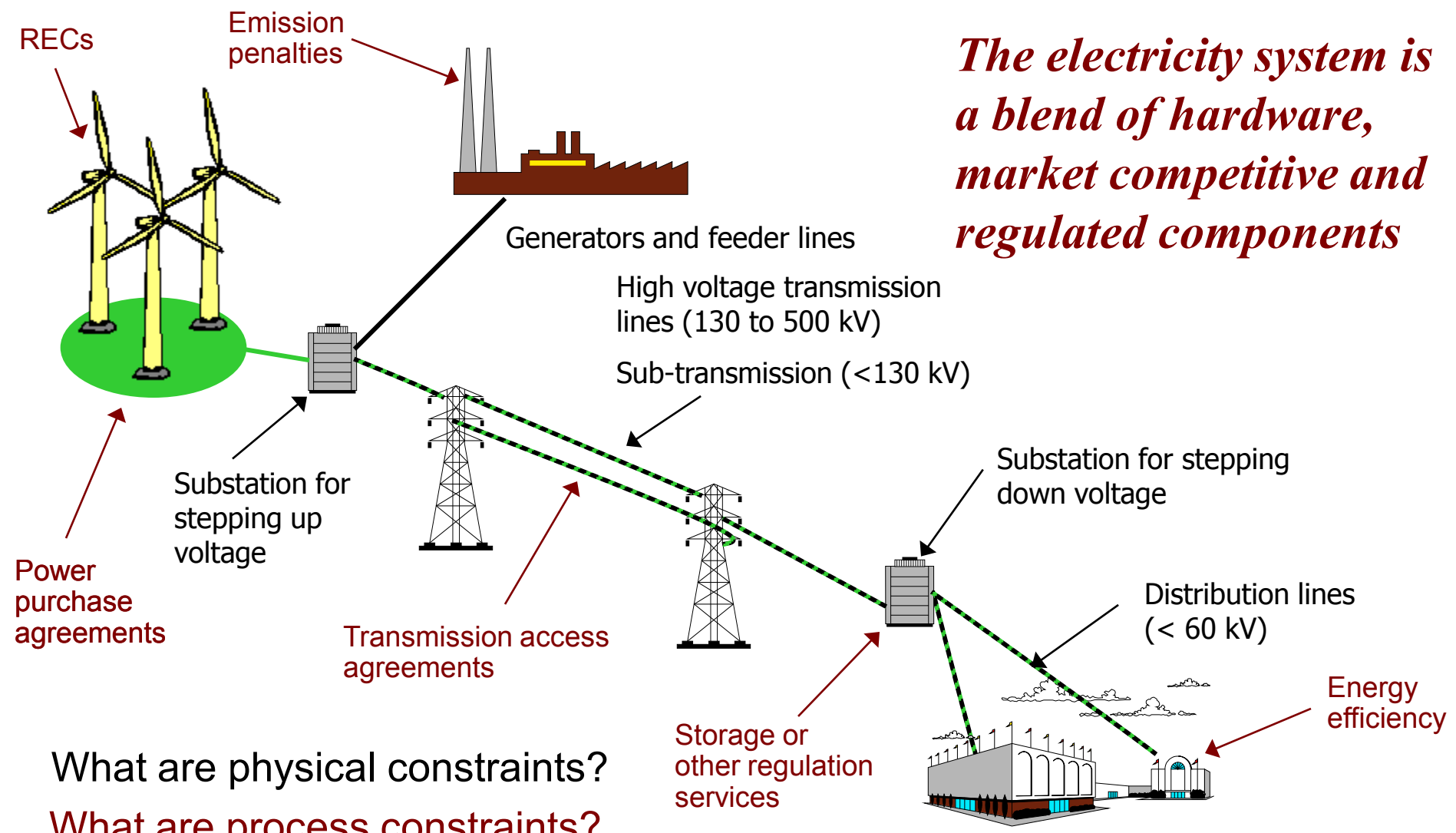
Components of the Grid

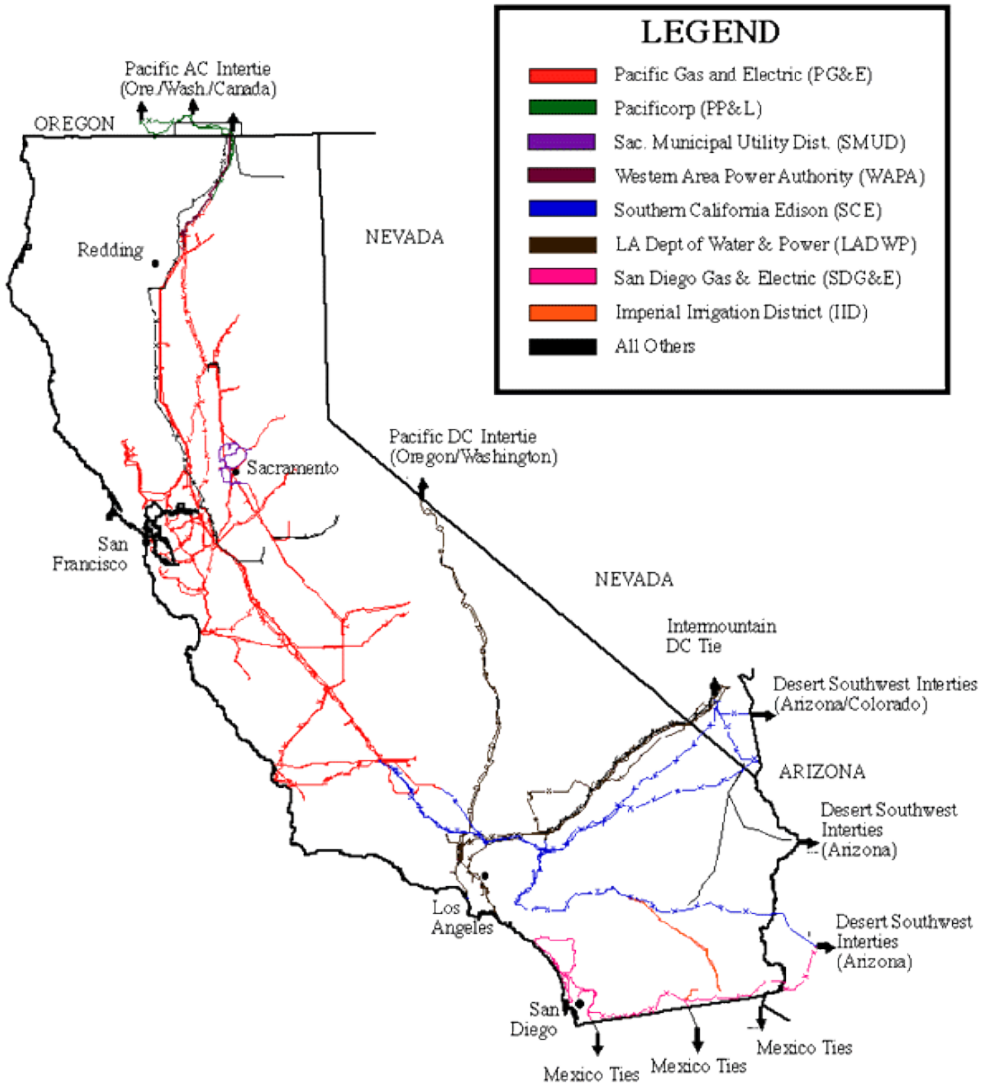


The electricity system is a blend of hardware, market competitive and regulated components

What are physical constraints?

What are process constraints?

Technology – Lay of the Land

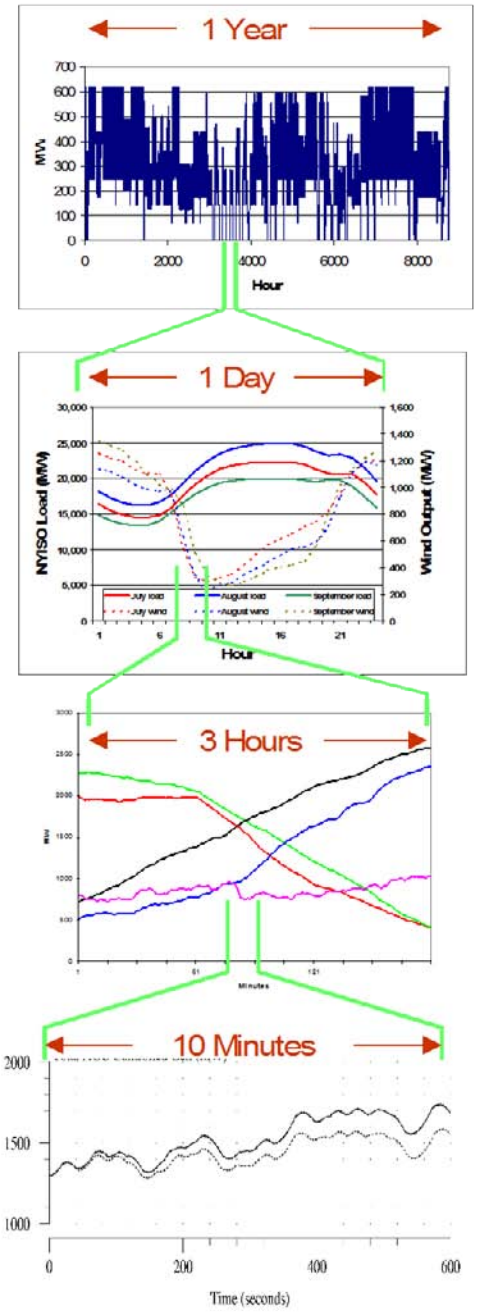


- Comprised of multiple utility service areas
- Mix of generation resources (base, peak, intermediate & intermittent)
- More than 124,000 miles of (T&D) power lines with over 2000 substations
- Supplies over 294 billion kilowatt-hours per year to 35 million Californians
- Electricity generation of over 61,000 MW supply electricity into California's grid
- 25% imported from out of state across high voltage DC lines

Planning and Daily Operational Needs

- Long-term Transmission Planning needs & Daily Operation needs are different
- Timescales for generation controls and performance vary across a wide range
- Added complexity due to market factors, technological maturity and infrastructure change

Time Frame	*Planning and Operation Process*	*Technology Issues*
Slower (Years)	Resource and Capacity Planning (Reliability)	Capacity Valuation (UCAP, ICAP) and Long-Term Load Growth Forecasting
	Unit Commitment and Day-Ahead Scheduling	Day-ahead and Multi-Day Forecasting
	Load Following (5 Minute Dispatch)	Hour-Ahead Forecasting and Plant Active Power Maneuvering and Management
Faster (seconds)	Frequency and Tie-Line Regulation (AGC)	Real-Time and Autonomous Protection and Control Functions (AGC, LVRT, PSS, Governor, V-Reg, etc.)

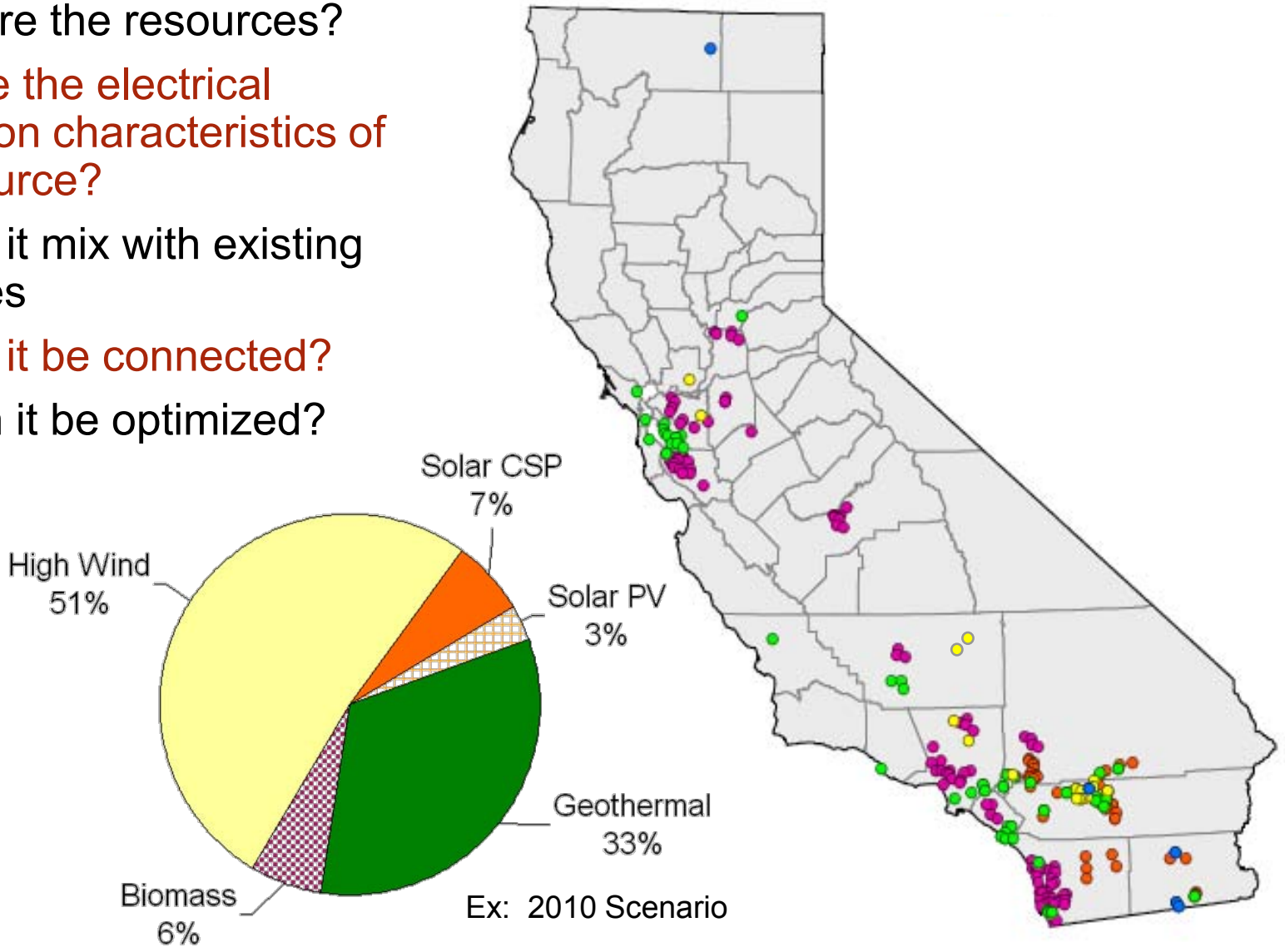


Begin to Pull Things Together

Examples of PIER and Renewable Energy Program efforts.

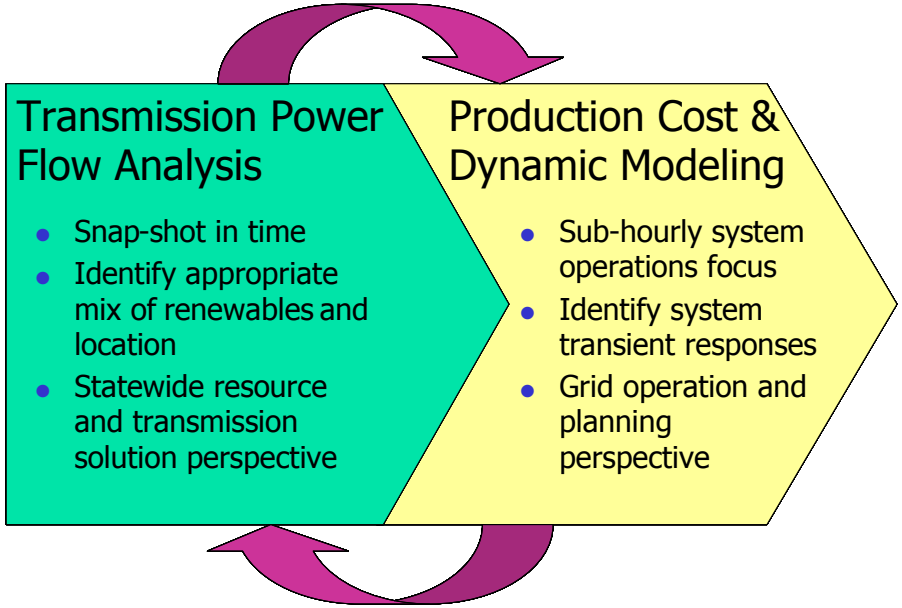
Developing Renewable Options

- Where are the resources?
- What are the electrical generation characteristics of the resource?
- How will it mix with existing resources
- How will it be connected?
- How can it be optimized?



Scenario-based simulations to develop options

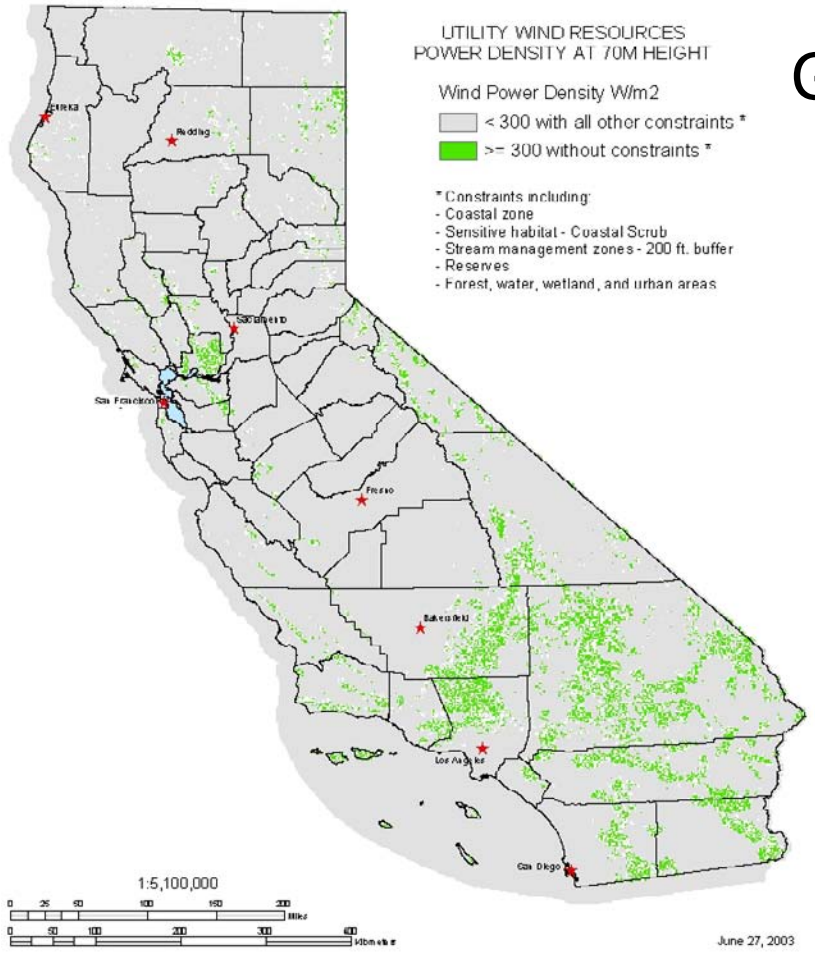
- Scenario-based analysis to help begin to pull things together from a state-wide perspective and explore options (Intermittency Analysis Project – IAP)
- Devising new tools and strategies to help communicate results



A Start to Pulling Things Together…

End-to-End Approach

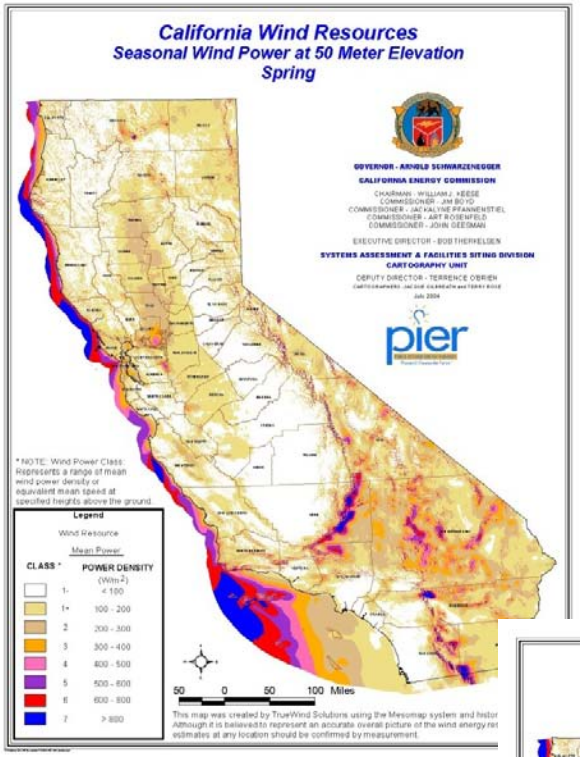
Refine Resource Assessments: Wind

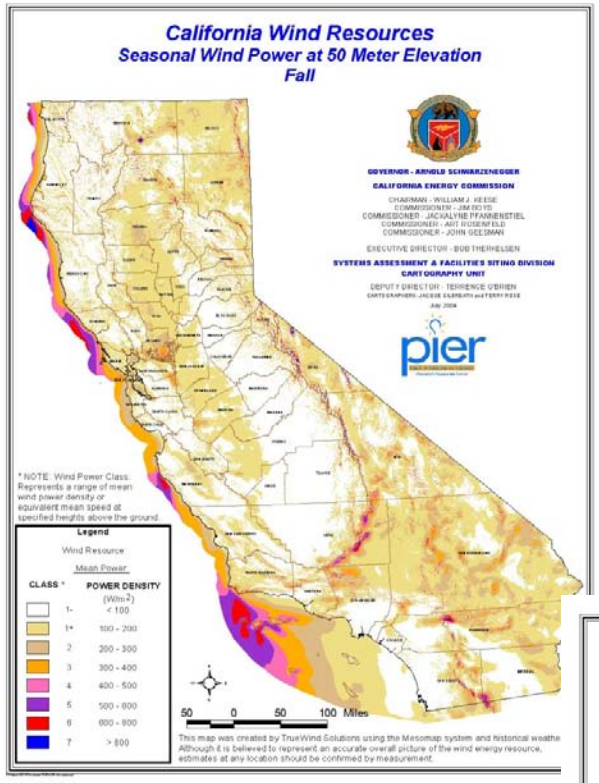


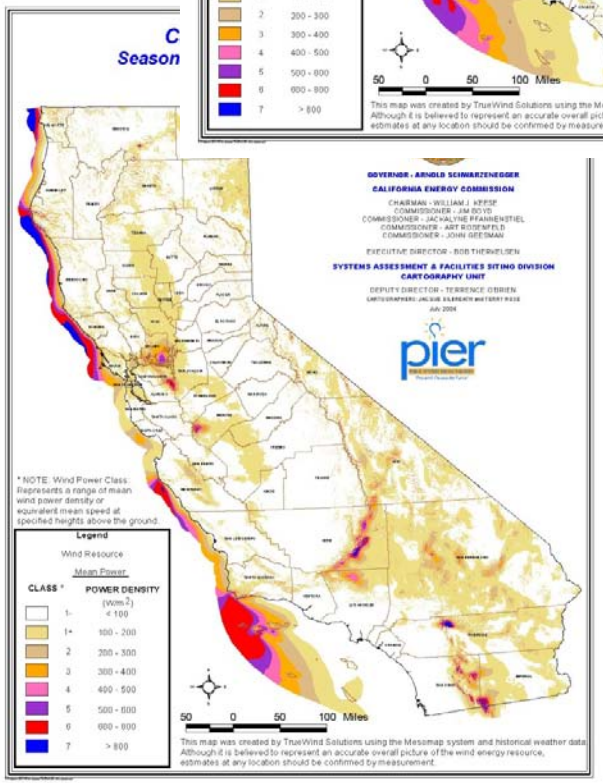
Gross Wind Potential: 295,187 MW
Technical Potential*: 99,945 MW
Current Installed: 2,130 MW
Opportunity: 97,815 MW

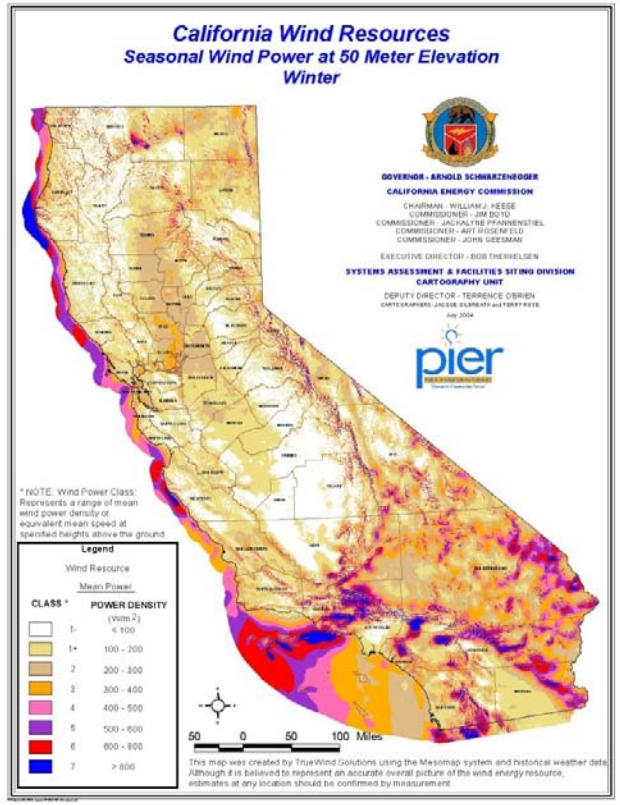
Technical Filters (excluded areas):*

Resource > 300 W/m ^{2}
Topography grade > 20%
Bodies of Water
Forested Areas
Urban Areas
State/National Parks & Monuments
Others (Natural Reserves)









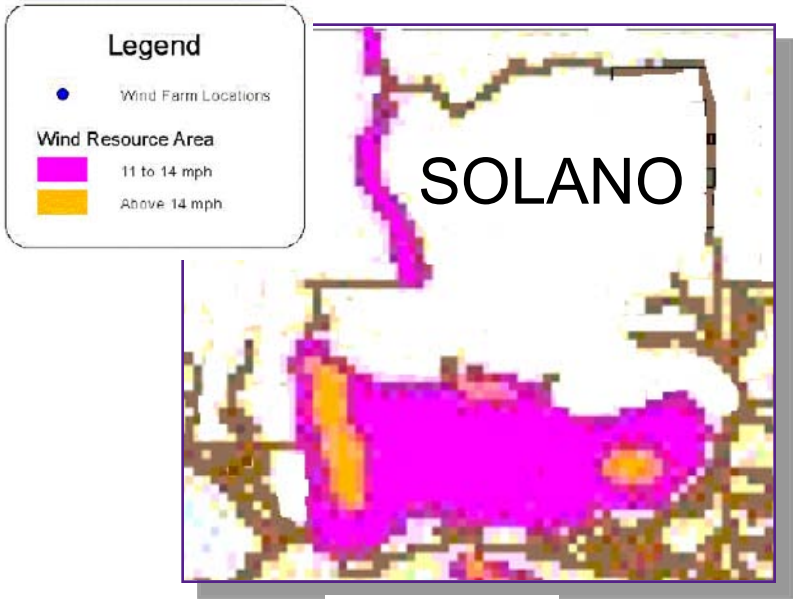
Understand Nature of Resources

Example of Wind Resource Forecasting Dependencies

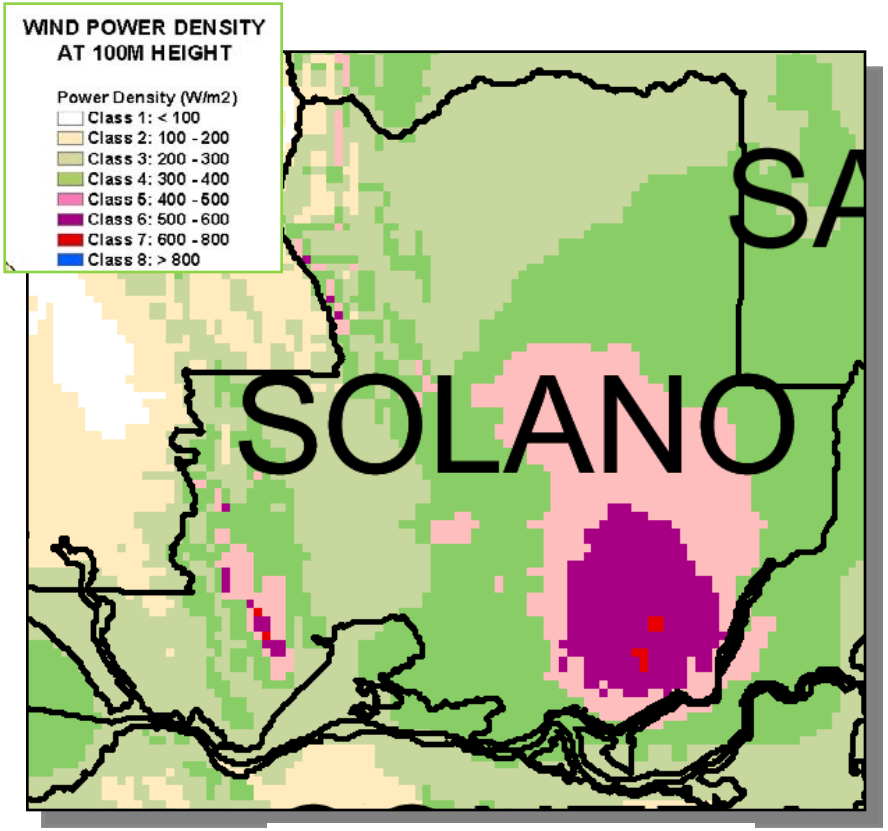
1. **Meteorology – Seasons**
2. **Geographic location**
3. **Topology**
4. **Data resolution**

Tools to Increase Data Quality & Confidence

Improvements provided by high-resolution maps



Old Map

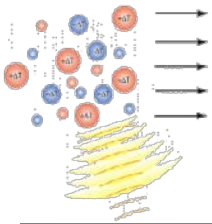


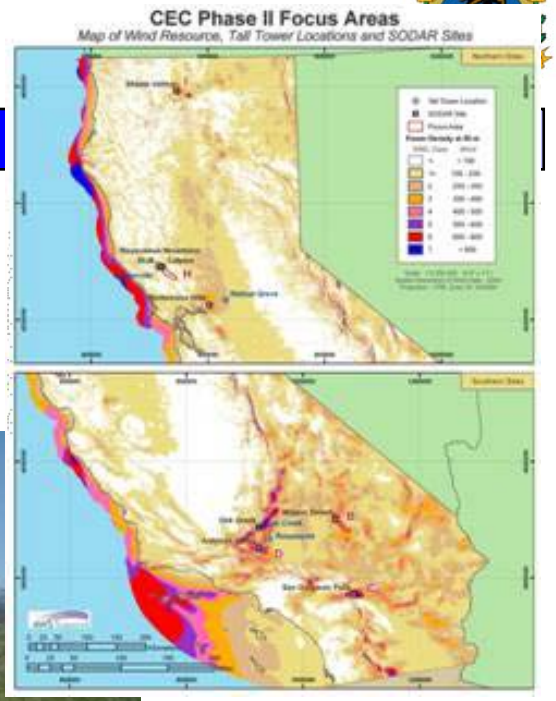
New Map and Data

- Refines wind resource locations and new development potential
- Identifies additional land area for wind development

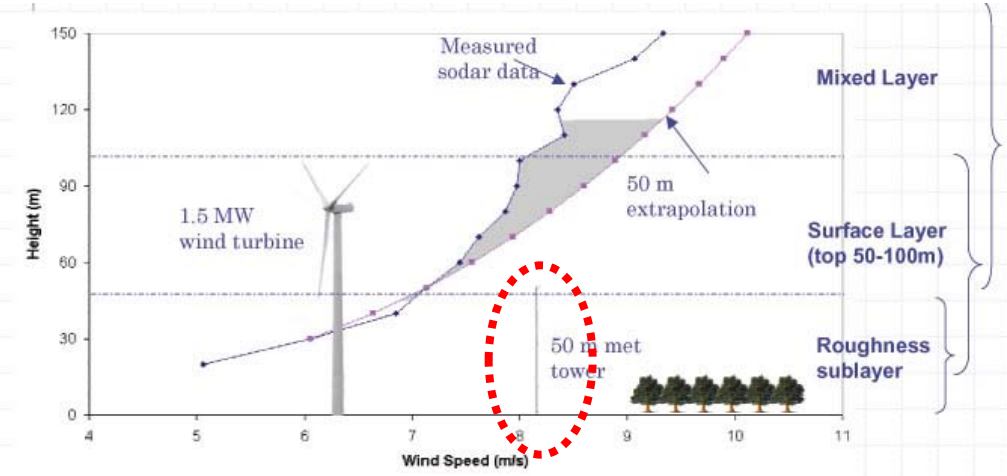
Reduce Technology Risks

- Responds to industry's need to acquire accurate, upper atmospheric wind data within the operating regime of current wind turbine technologies
- Enables wind data to be remotely measured at elevations of 50m to 200m – typical heights of new turbine technologies
- Reduces development risk at new sites with wind data substantiated by tall tower and SODAR measurements
- Improves wind plant power prediction for energy generation and wind energy forecasting
- Industry participation: Calpine, Oakcreek, Enxco
- Need measurement locations





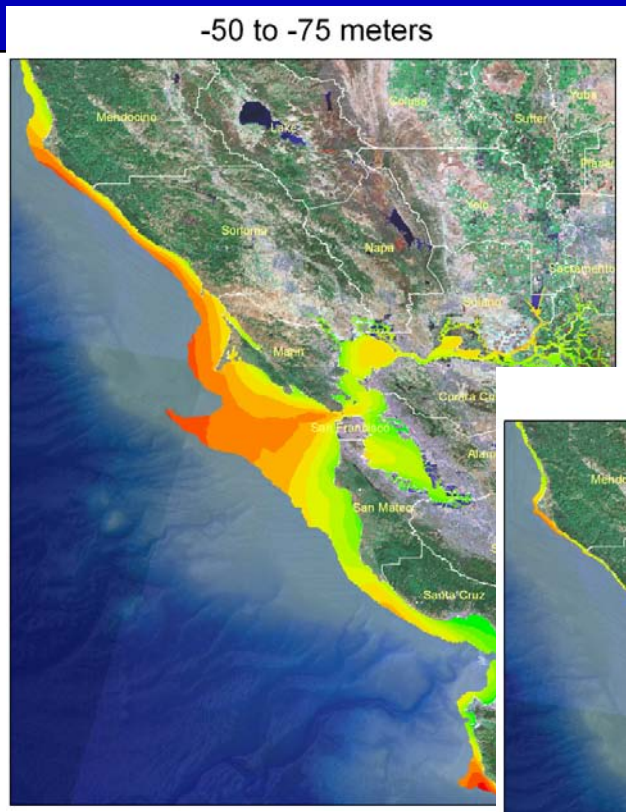
SODAR unit in the field

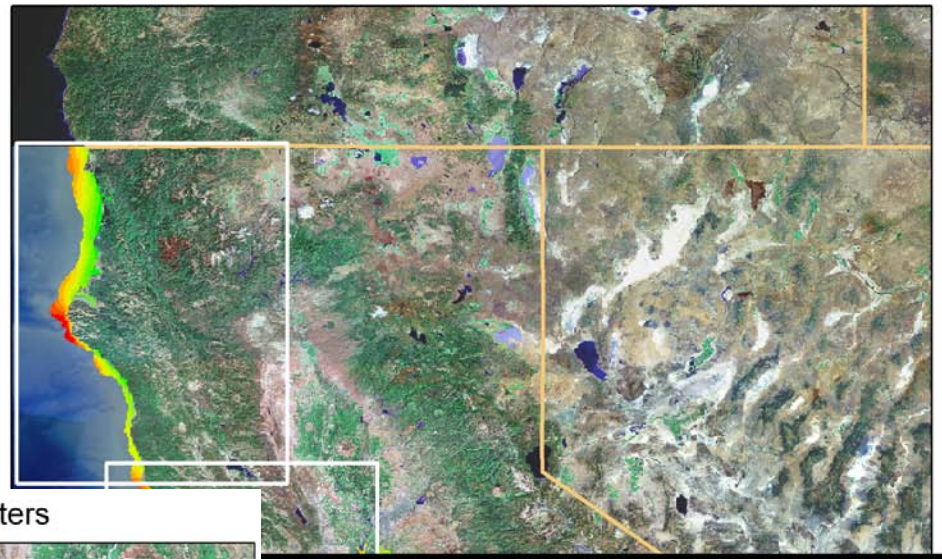


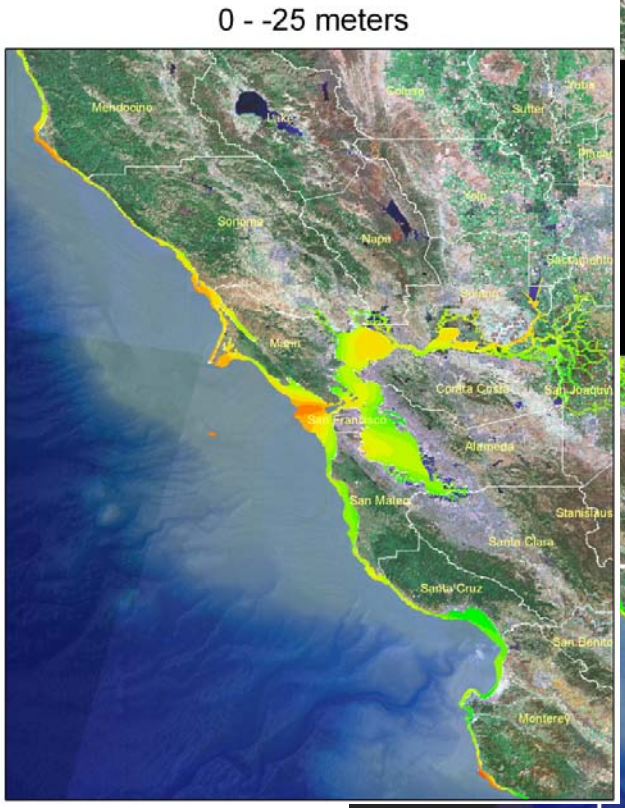
Communicate & Disseminate Information

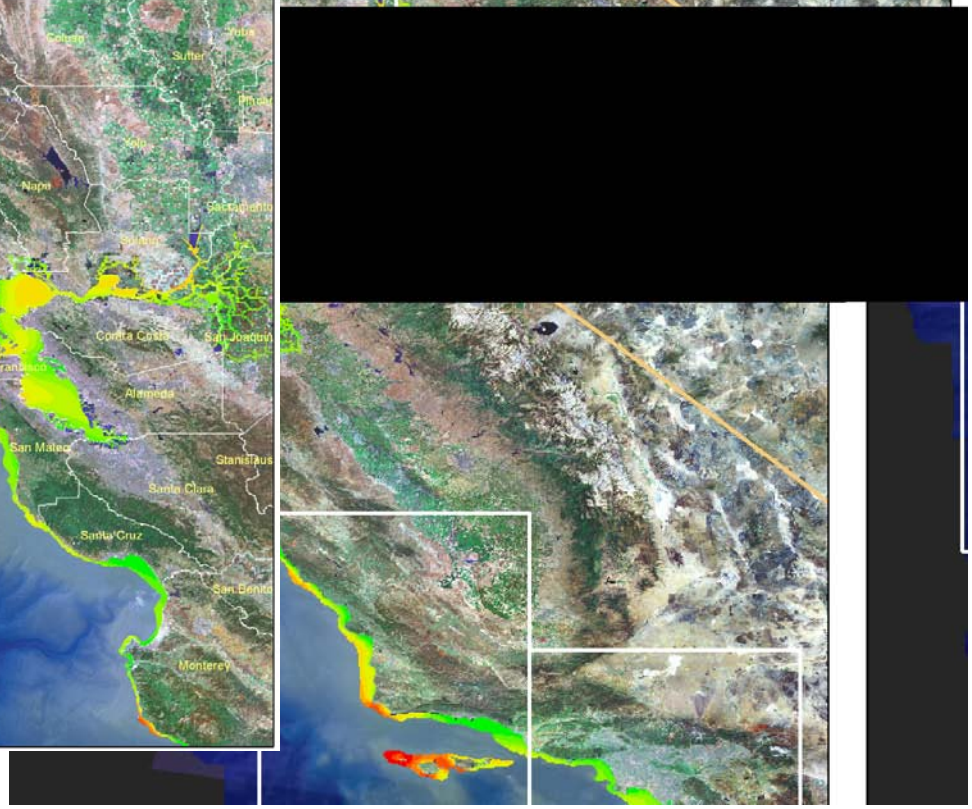
http://eed.LLNL.gov/renewable

Explore New Resources









Bathymetry

Depth in meters

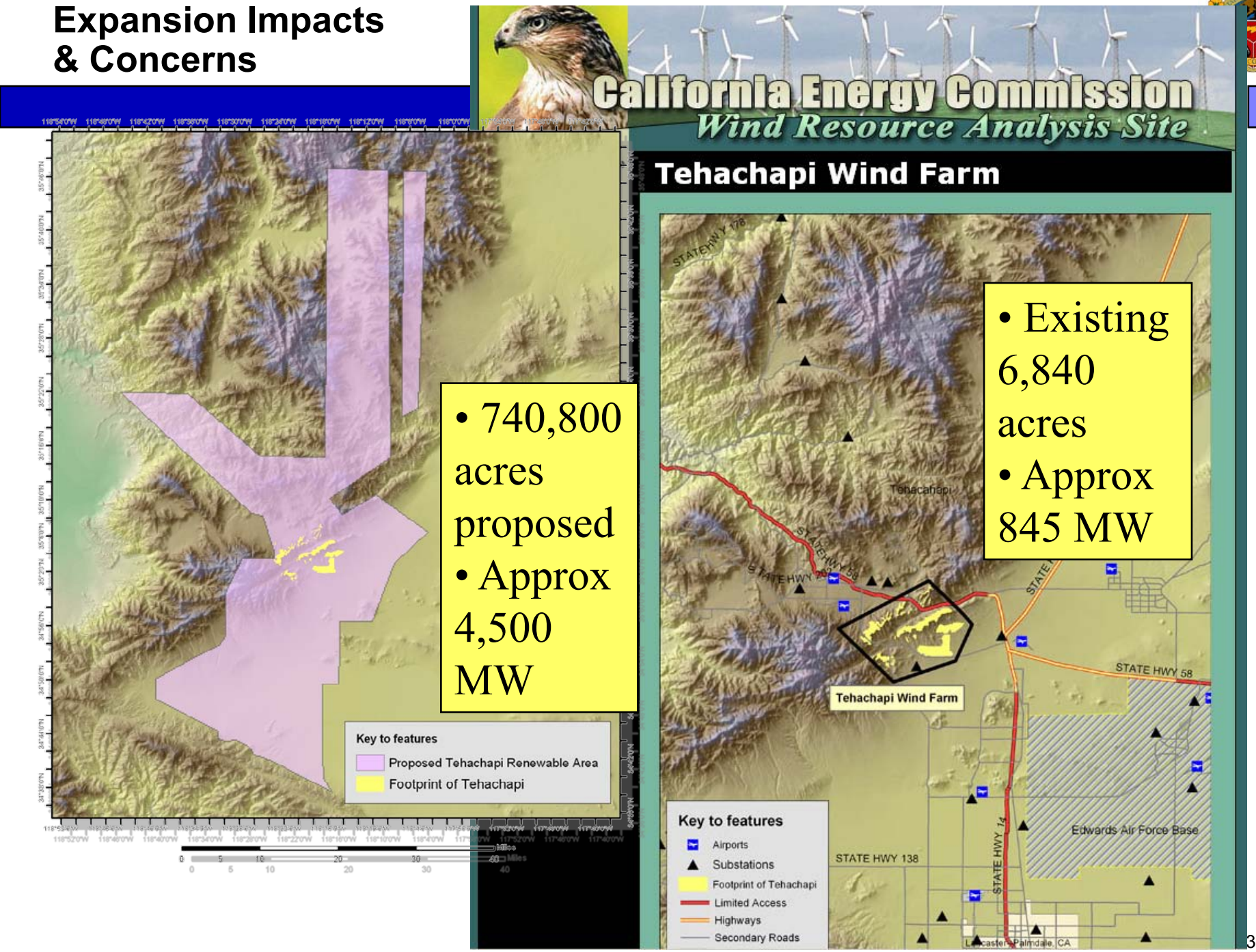
High : 0

Low : -4380

Wind speed (m/s) at 70m height

- Class 1: <4.5
- Class 2: 4.5 - 5.0
- Class 3: 5.0 - 5.5
- Class 4: 5.5 - 6.0
- Class 5: 6.0 - 6.5
- Class 6: 6.5 - 7.0
- Class 7: 7.0 - 7.5
- Class 8: 7.5 - 8.0
- Class 9: 8.0 - 8.5
- Class 10: > 8.5

Expansion Impacts & Concerns



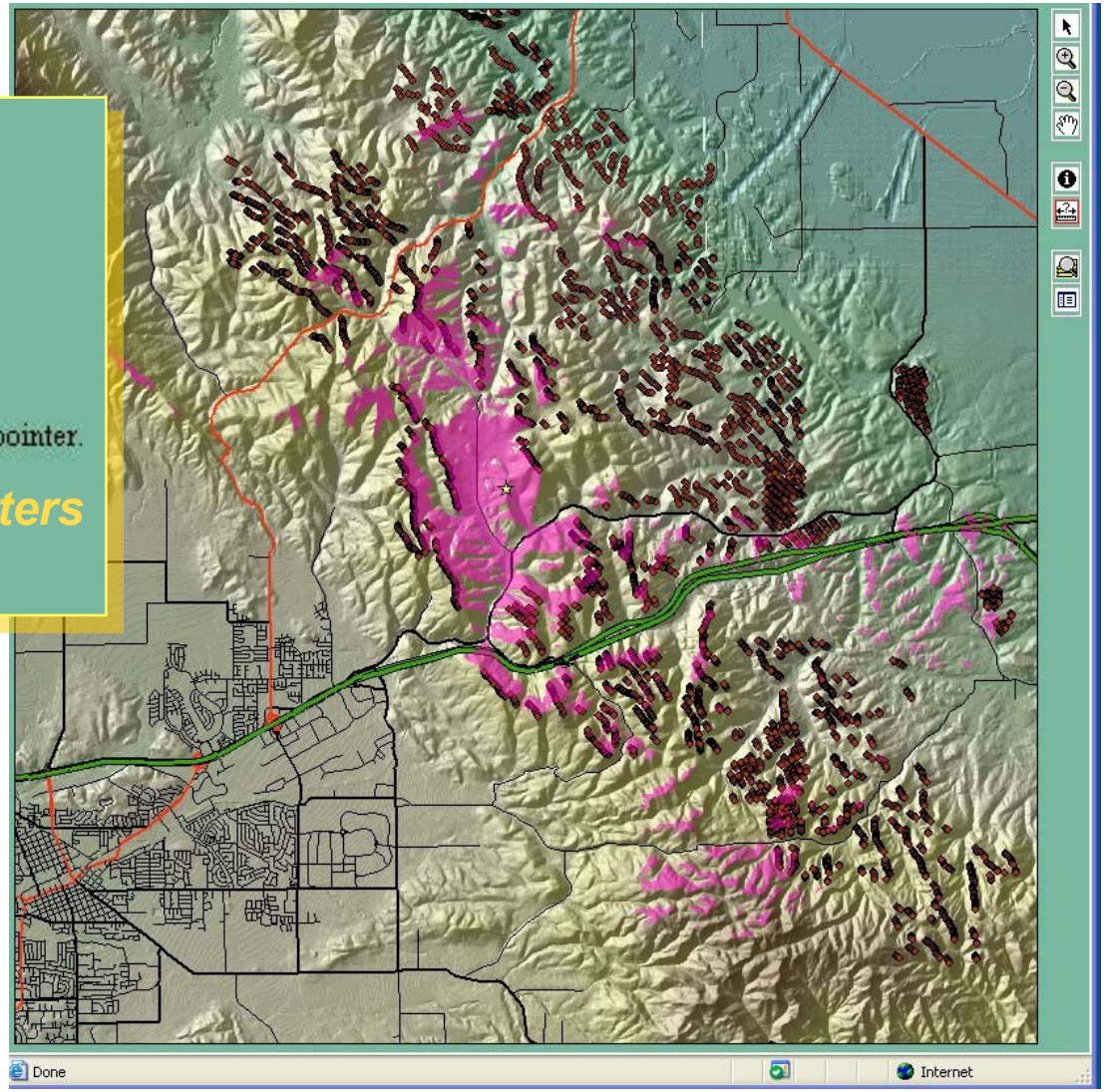
Assess Cultural, Community and other Land Impacts

Do Visibility

1. Change observer height and radius (if needed).
   Height of observer: 60 meters
   Radius from observer: 10000 meters
2. Place observer by clicking on the map with the + pointer.

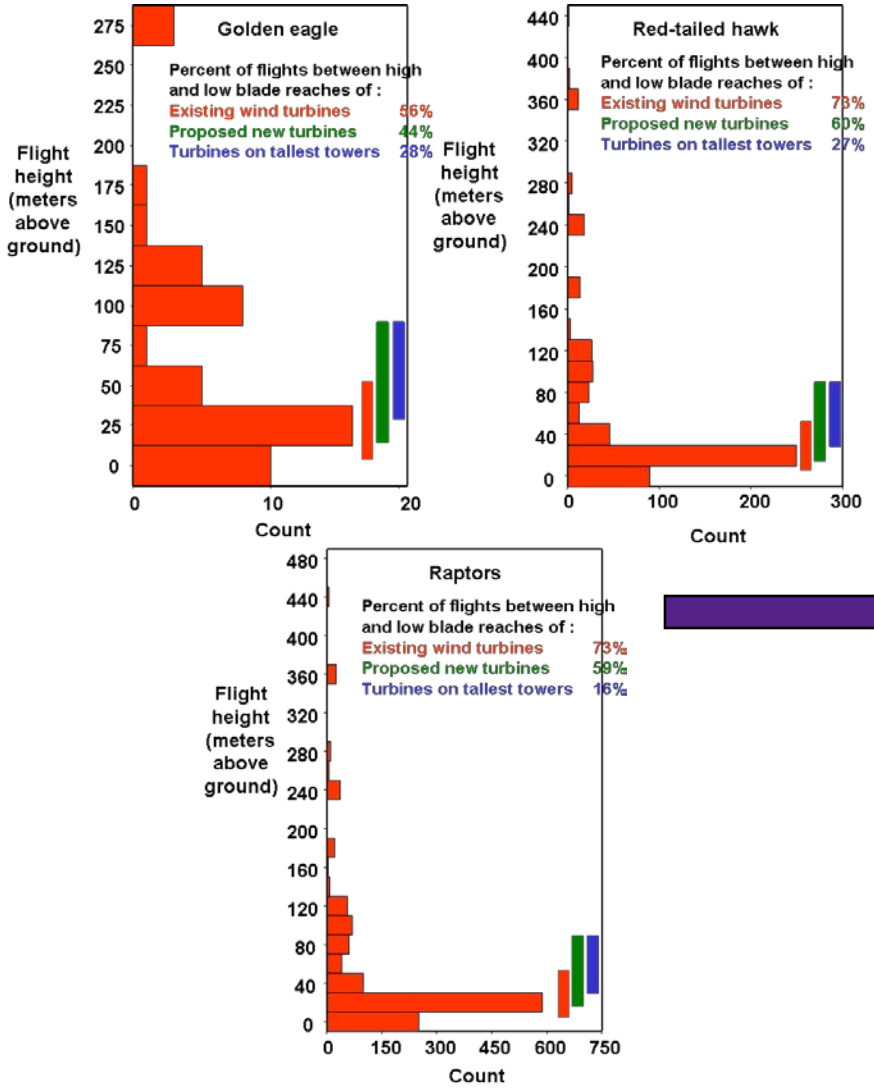
User defined analysis parameters

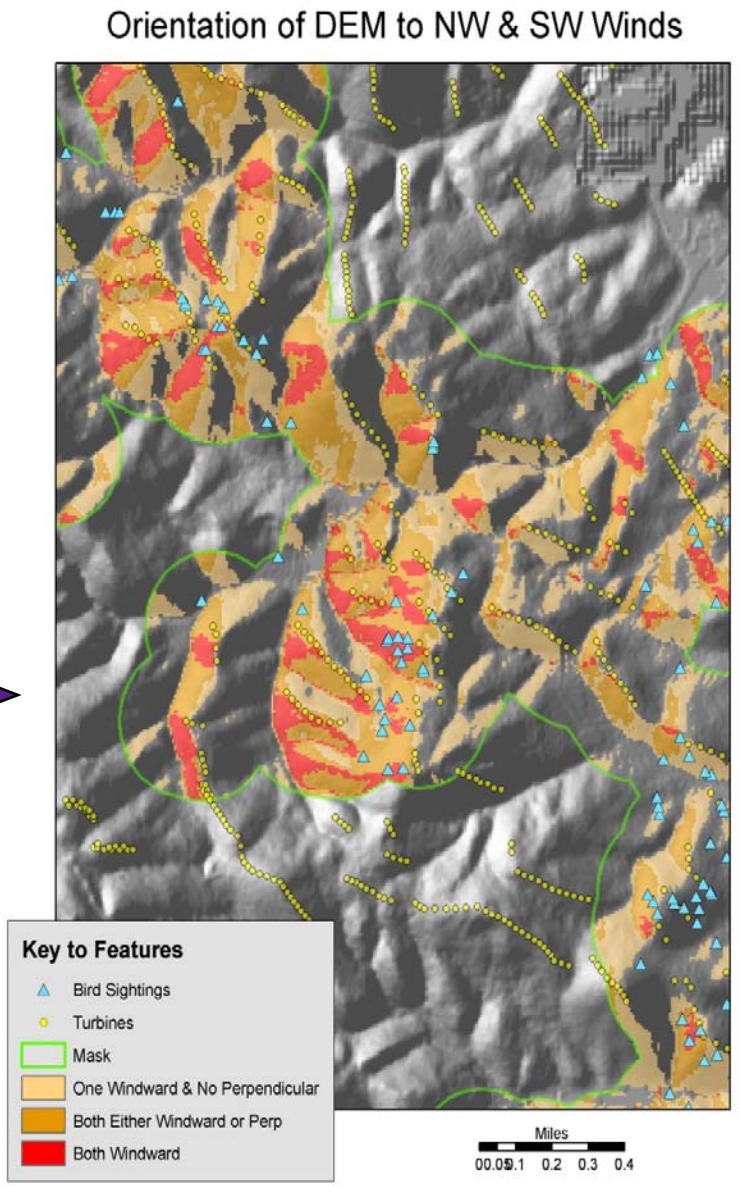
Done / Finished



Allows users to perform impact analysis by choosing a turbine hub height, a coverage area and then calculate land that the light source is visible from

Understand Impact on Nature

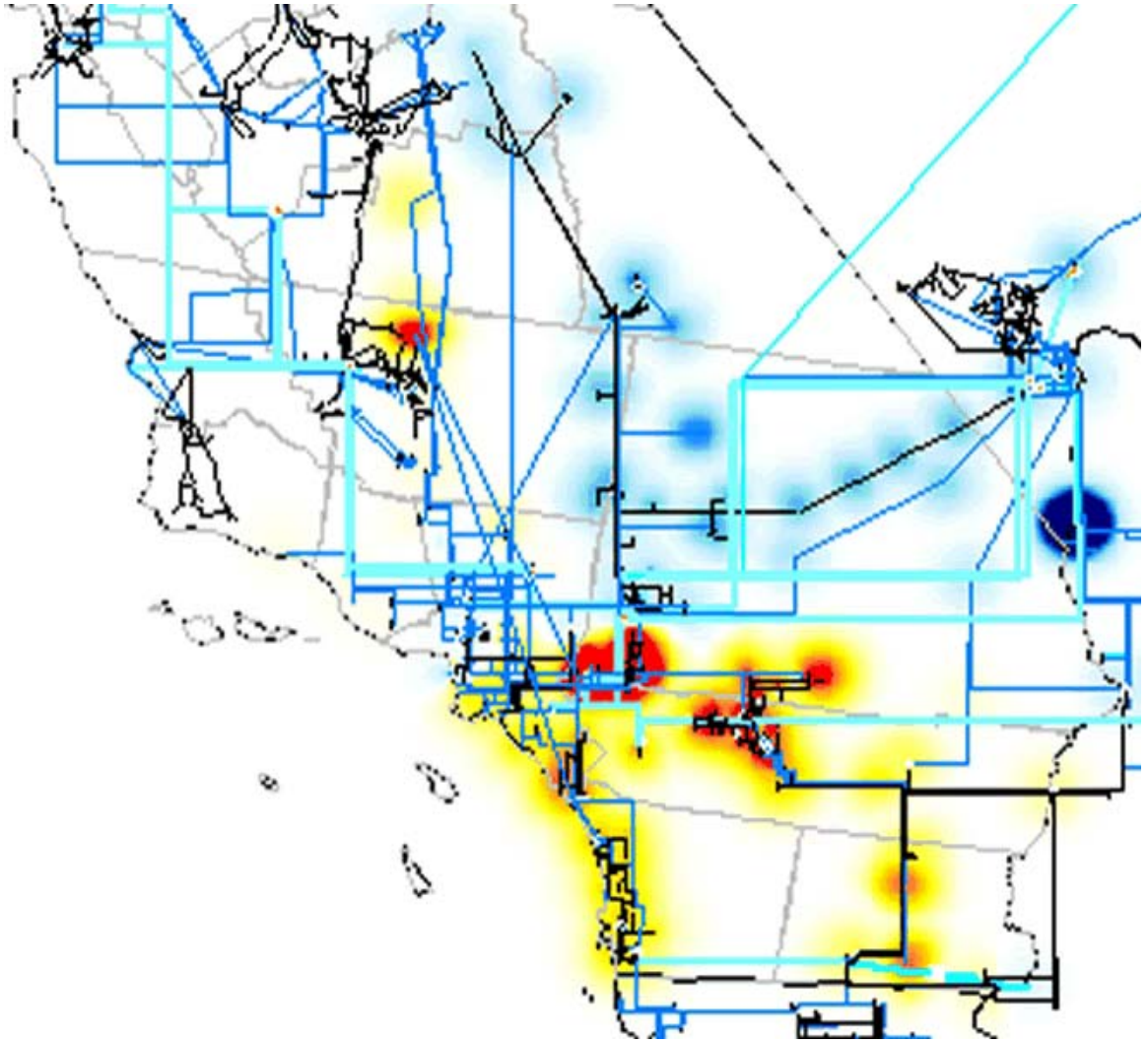




Series of statistical data converted into more comprehensible graphical data analysis layers. Results translate in locations where wind turbines may be re-sited to have less impact on the avian mortality

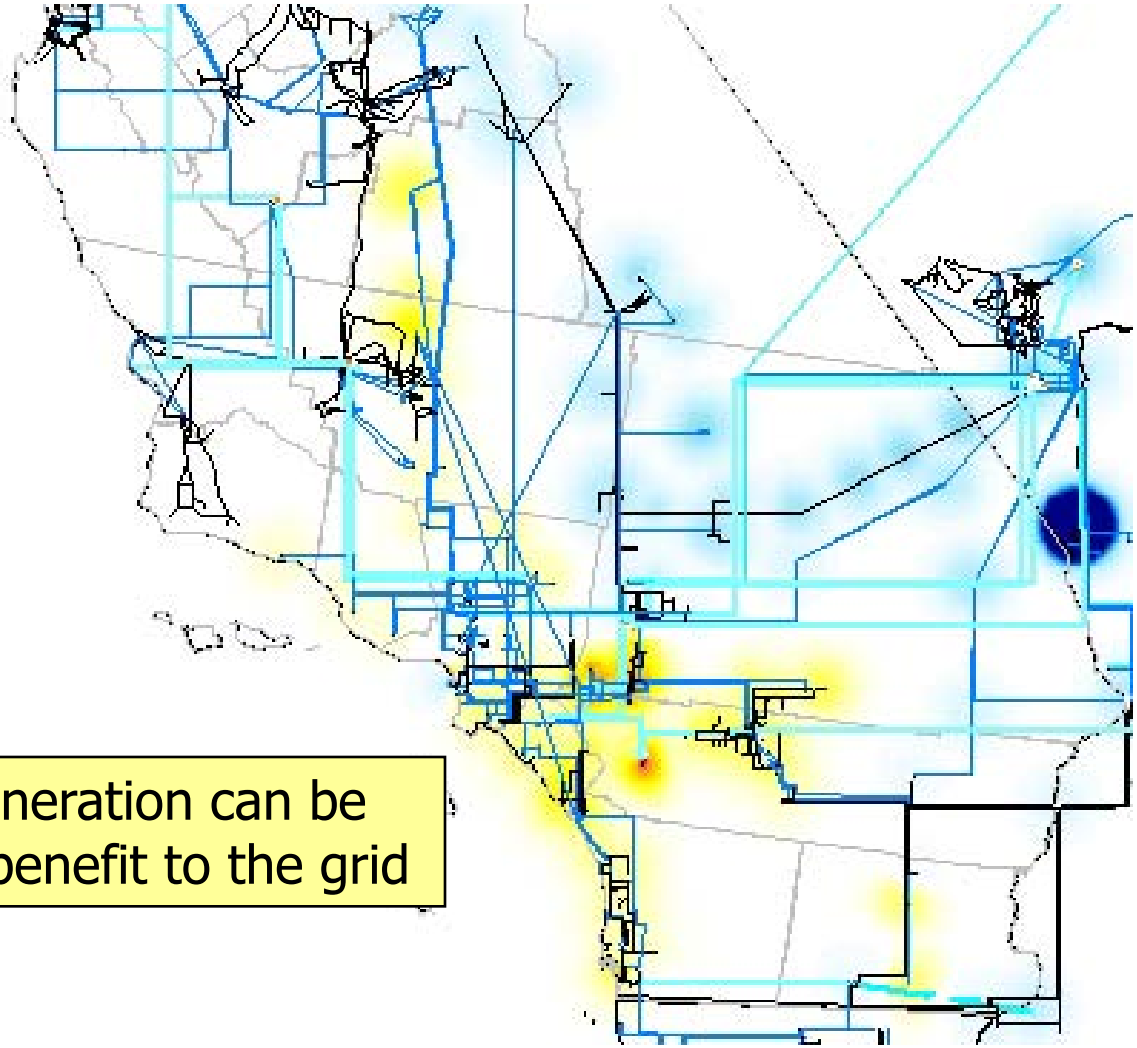
Reduce Transmission Congestion

- Compute Transmission Loading Relief Sensitivities to find high impact buses
- Transmission congestion areas or "hot spots" ranked by areas where new generation would be beneficial
  - Red area highest ranking
  - Yellow area next highest
  - Blue area least desireable



After Renewable Injection

- Strategically located resources reduces "hot spots" significantly
- Overall system benefit by injecting resources at location



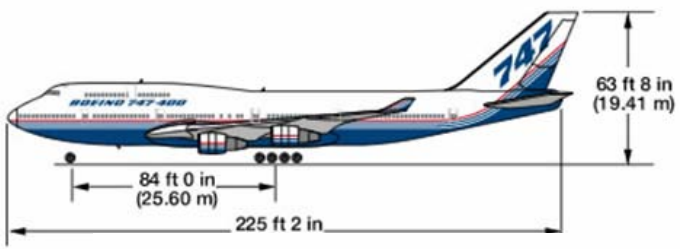
Shape were renewable generation can be placed to provide overall benefit to the grid

Plan for Renewable Resource Seasonality and Geographic Diversity

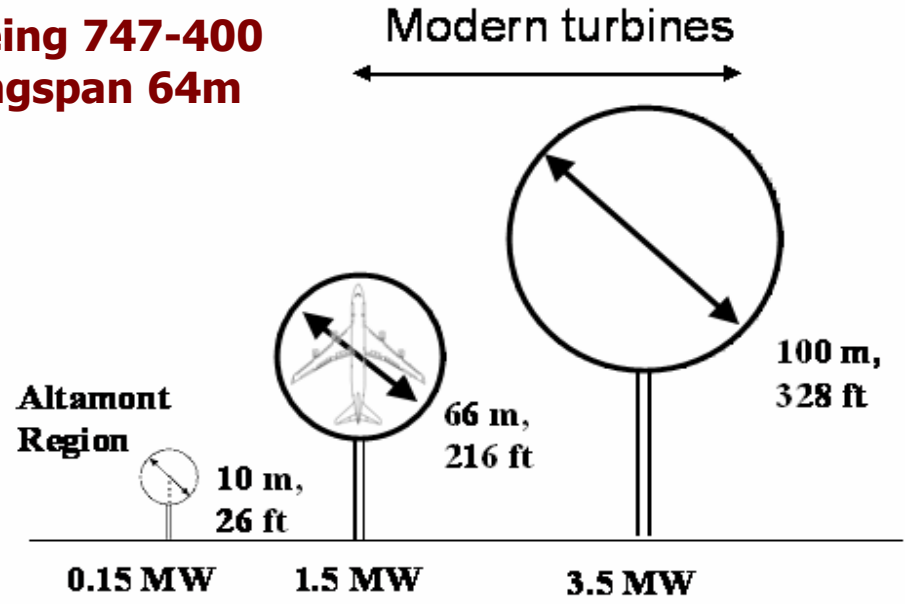
Region	Resource	Spring	Summer	Fall
Medicine Lake	**Geothermal**	X	Neutral	X
Imperial Valley	**Geothermal**	X	Neutral	
Sulfur Bank	**Geothermal**			Neutral
LADWP	**Wind**		X	X
Altamont Pass	**Wind**	X		
Solano	**Wind**	X		X
Tehachapi	**Wind**		Neutral	X
Central Valley	**Biomass**			X
SDG&E	**CSP**		Neutral	Neutral
SCE	**CSP**			Neutral
Residential	**PV**			Neutral

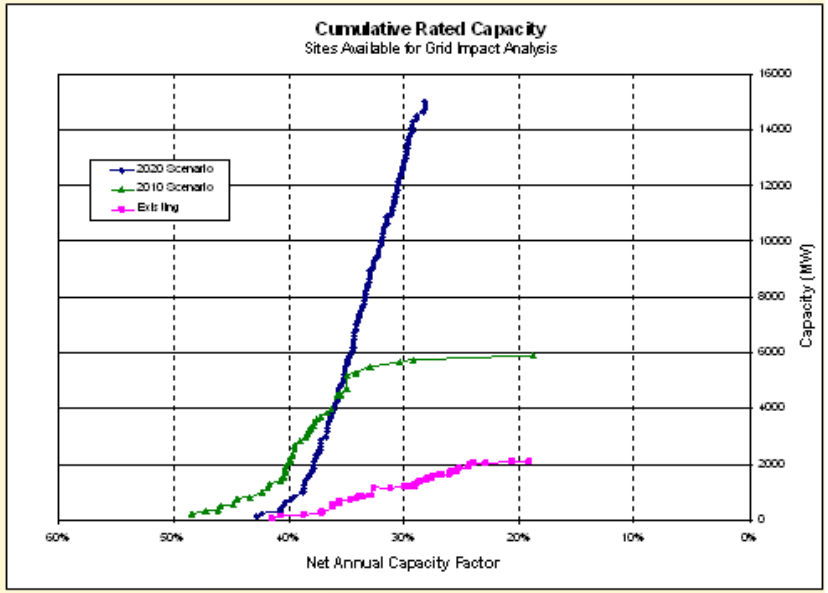
Factor Change in Technologies

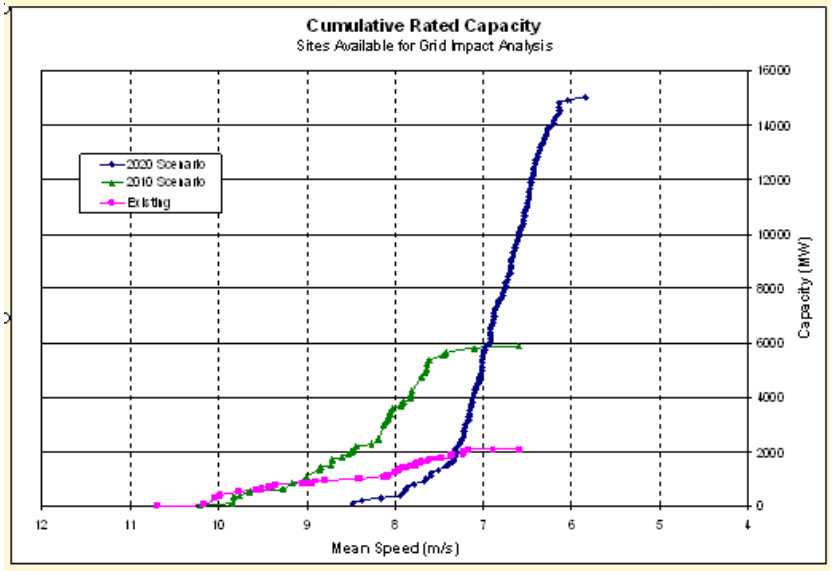
- Phase out of older technologies
- New performance capabilities
- New grid-friendlier advance power electronics and controls



Boeing 747-400
Wingspan 64m

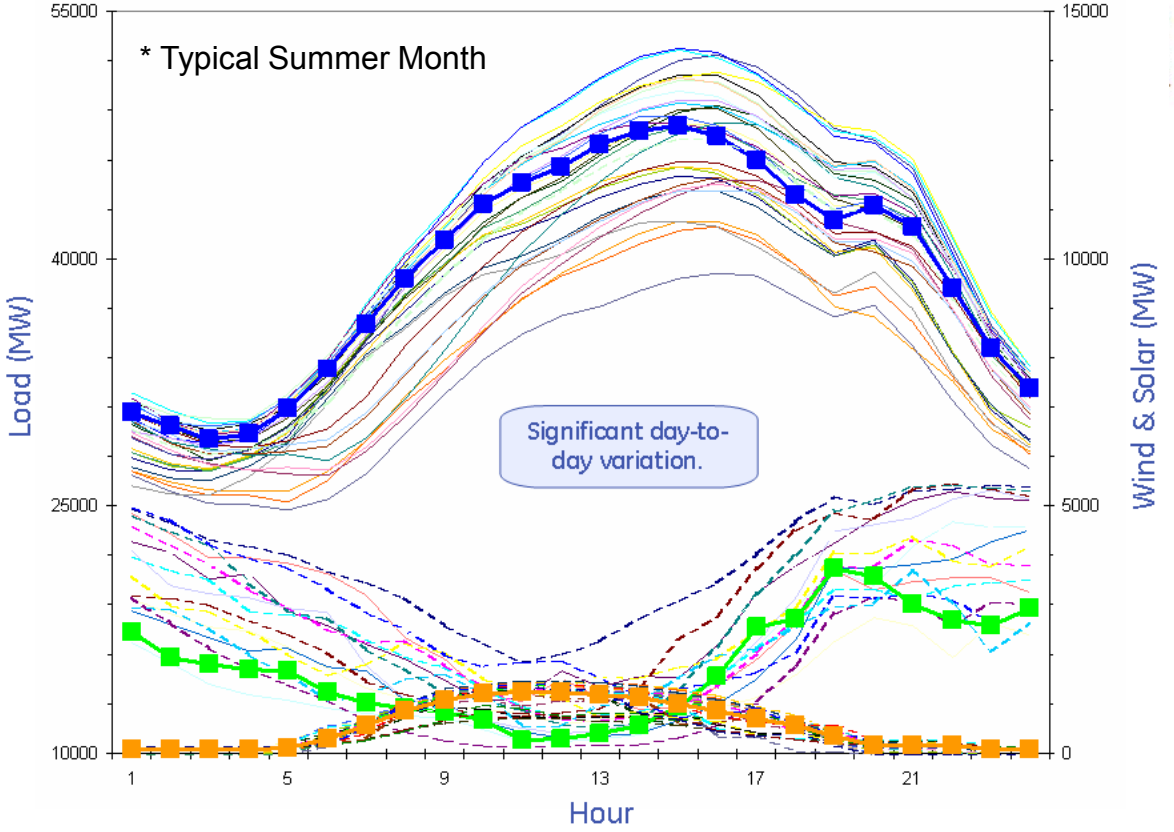






Managing the Mix

- Striking a balance between changing demand and supply
- Do it at the least cost
- Do it without sacrificing reliability
- Do it so it can be sustained



Current Paradigm

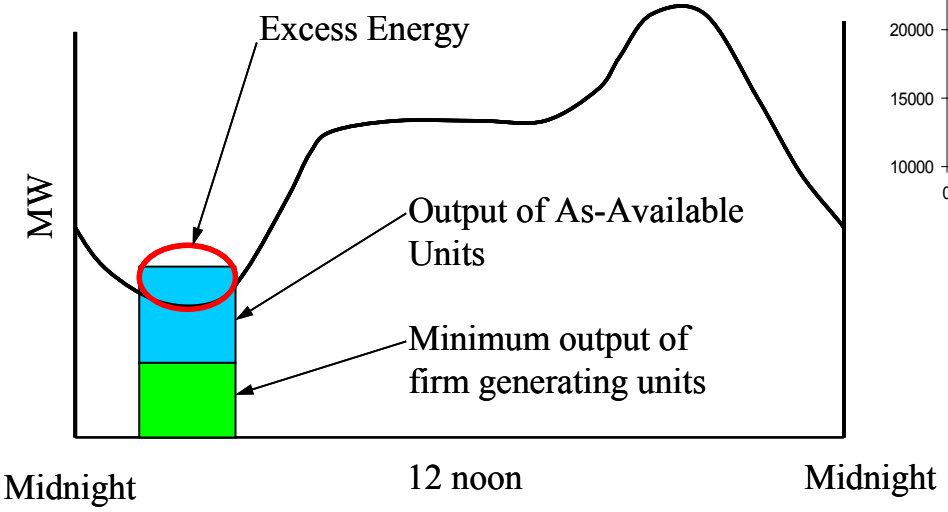
$$Demand = Supply$$

Emerging Paradigm

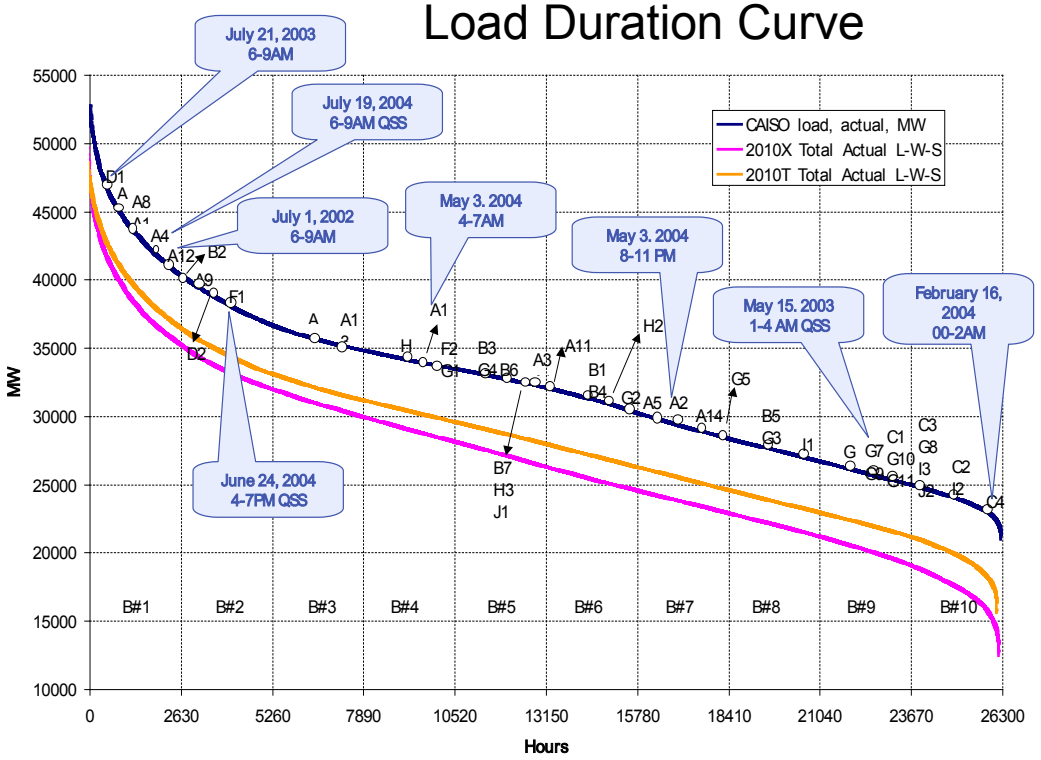
$$Demand = Supply + \sum_{0}^{\infty} VariableSupply$$

Understand the Time Periods of Interest & Value

- Limiting Conditions & Duration
  - July morning, load rise
  - February night, light load
  - June evening, load decrease
- Hourly and sub-hourly periods of analysis

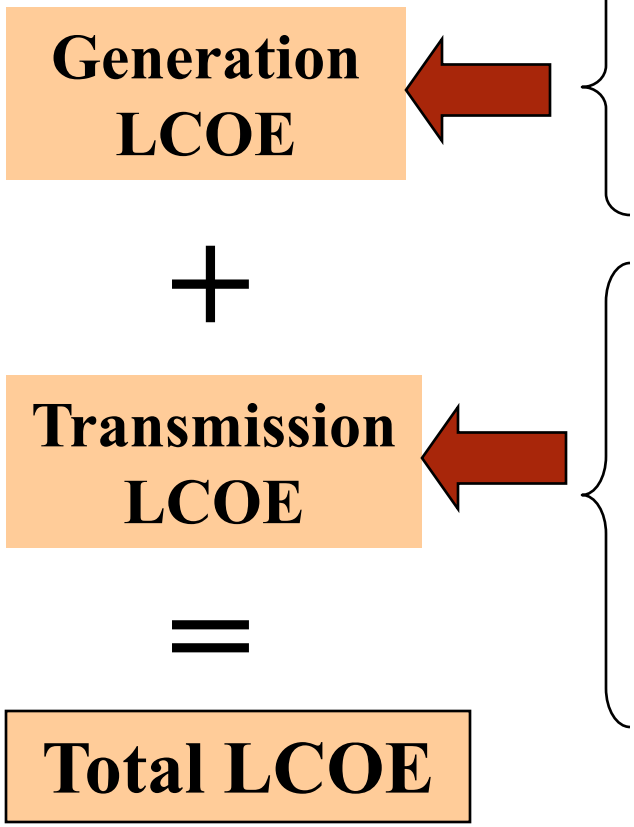


Load Duration Curve



What to do with the excess energy?
- Today's solution
- Tomorrow's solution
- Permanent solution

Consistent Economic Valuation

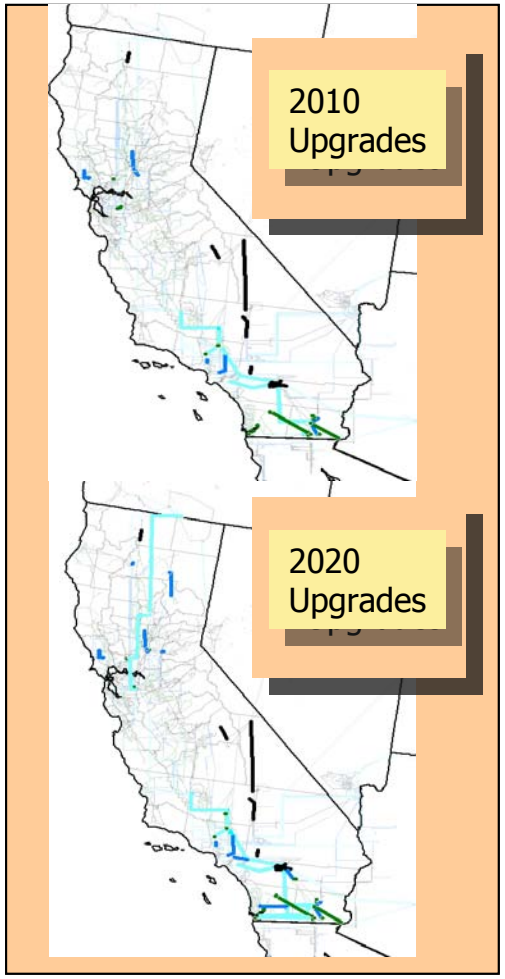


- Standardized LCOE by technology and year
- Estimated interconnection requirements (no right of ways)
- Financial parameters consistent with those applied to the generator

Cost Projections for Expansions

* **Order of magnitude estimates based on N-1 contingency, lines greater than 230kV**
* Transmission plans and additions based on combination of utility projects and IAP team assessed needs

Line Voltage	2010 Line Segments	2020 Line Segments	2010 Transformers	2020 Transformers
500	8	22	2	9
230	8	38	6	18
161/138	0	2	1	0
115	49	49	9	5
Below 110	13	17	14	8
Total #	**78**	**128**	**32**	**40**
Estimated Cost*	**$1.3 Bil**	**$5.7 Bil**	**$161 Mil**	**$655 Mil**



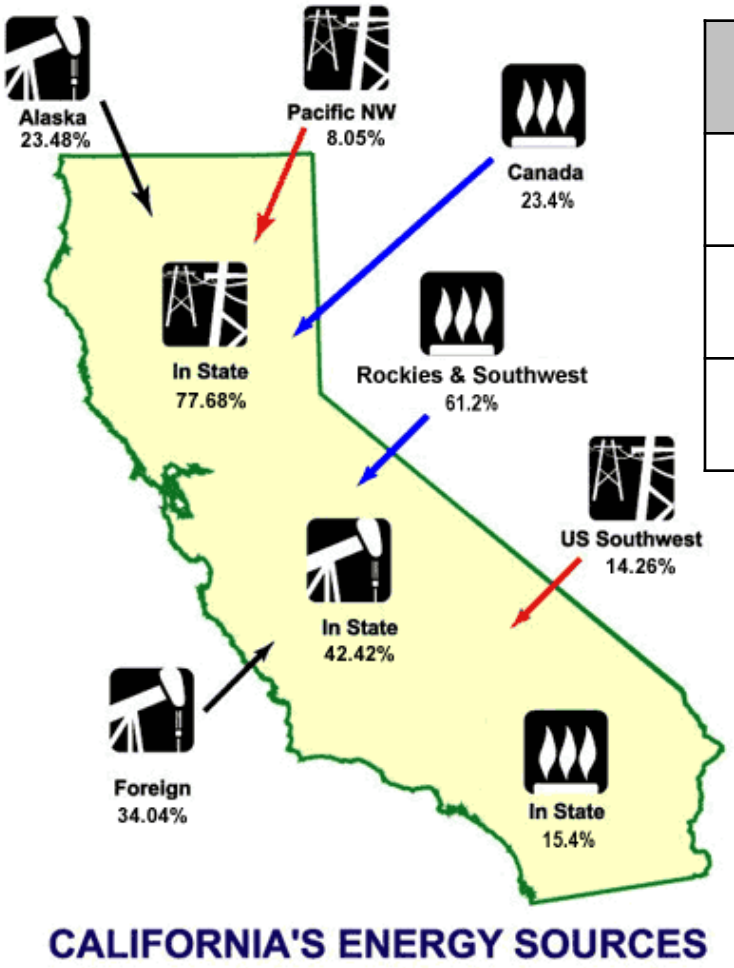
Capturing Other Renewable Benefits

** Based on 2020 IAP Scenario*	**In-State (CA)**	**WECC**
NOx reduction	520 tons	4,000 tons
SOx reduction	700 tons	2,000 tons
CO2 reduction	~ 8 Mil tons	~ 23 Mil tons
Natural Gas Reduction	140 Bil ft^3/yr	390 Bil ft^3/yr

Continuing to Quantify Public Benefits

- Methodology to evaluate technical and economic impact of renewable resources on transmission grid
- Continue to partner with industry to gather appropriate data to monitor, trend and consider system change impacts
- Refined technical potential for renewables incorporating environmental and social aspects
  - Reduce
    - Pollution and emissions
    - Wildfires
  - Increase
    - Employment - economy
    - Education & training
    - Safety
    - Customer electricity choice
    - Generating resource diversification
    - Independence from fossil resources

Look Outside of Boundaries

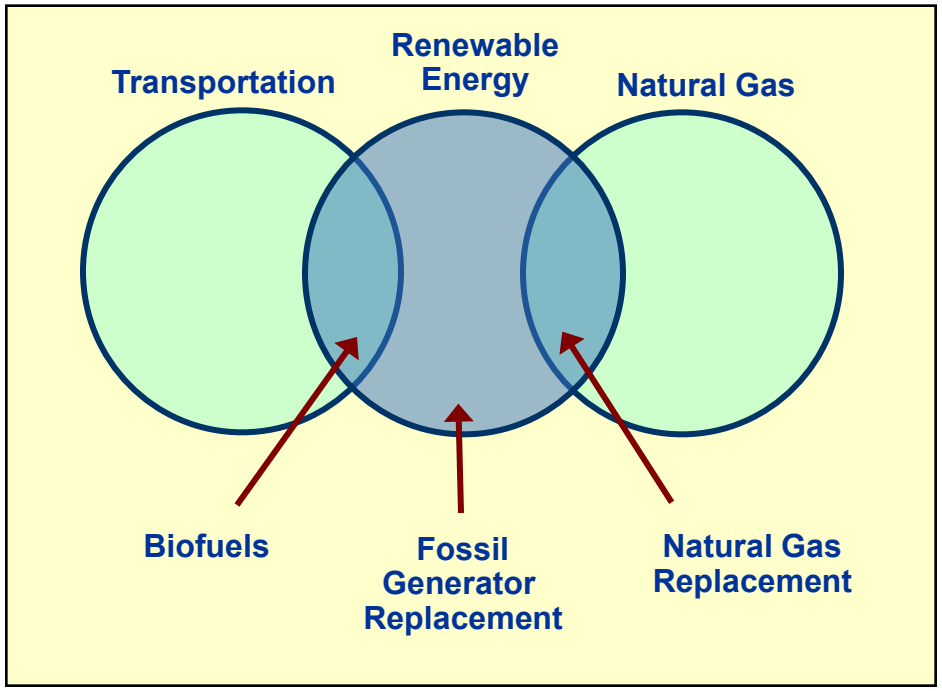


Forecasted Wind Potential

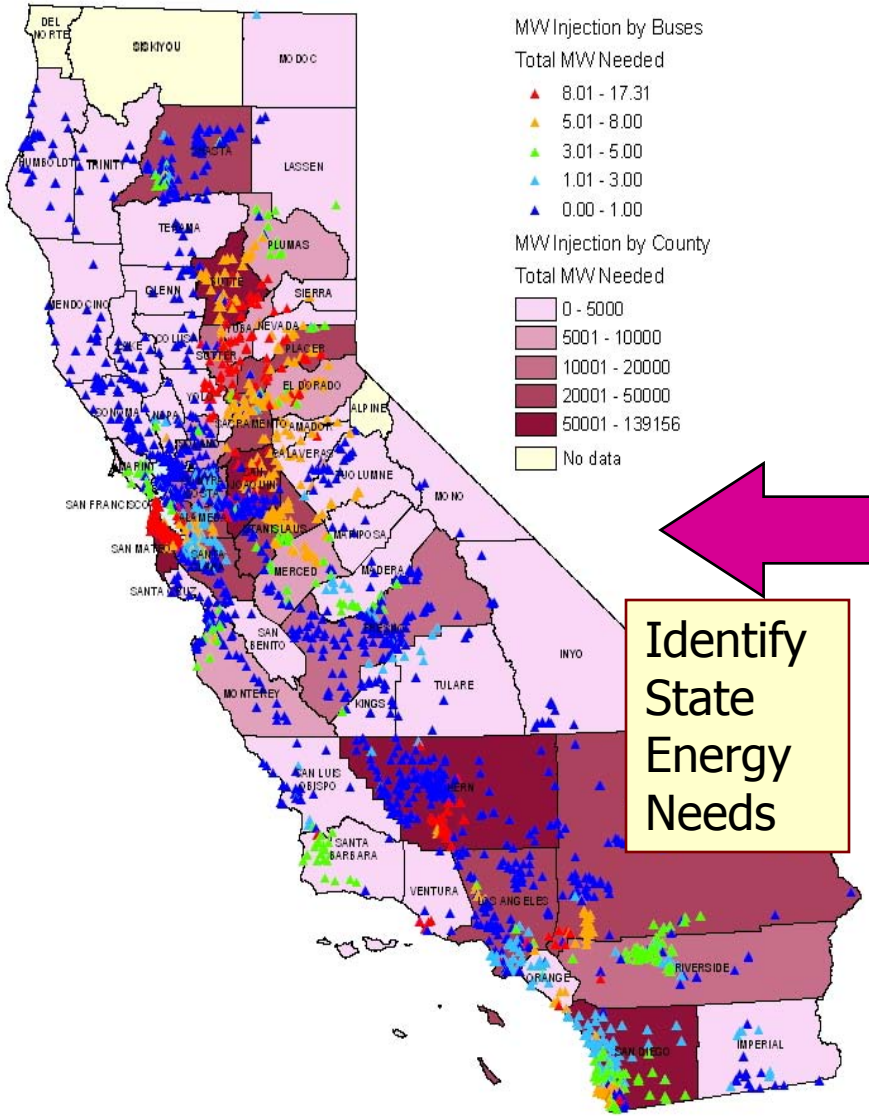
State	MW	GWh/year
Arizona	1,540	5,000
Nevada	17,000	55,000
Oregon	21,600	70,000

Law of Unintended Consequences

- Planning needs to consider the “law of unintended consequences”
  - Operational Impact due to replacing existing generators with renewables
  - Climate & Ecological change
  - Land Use
  - Water Use
  - Industry Shift

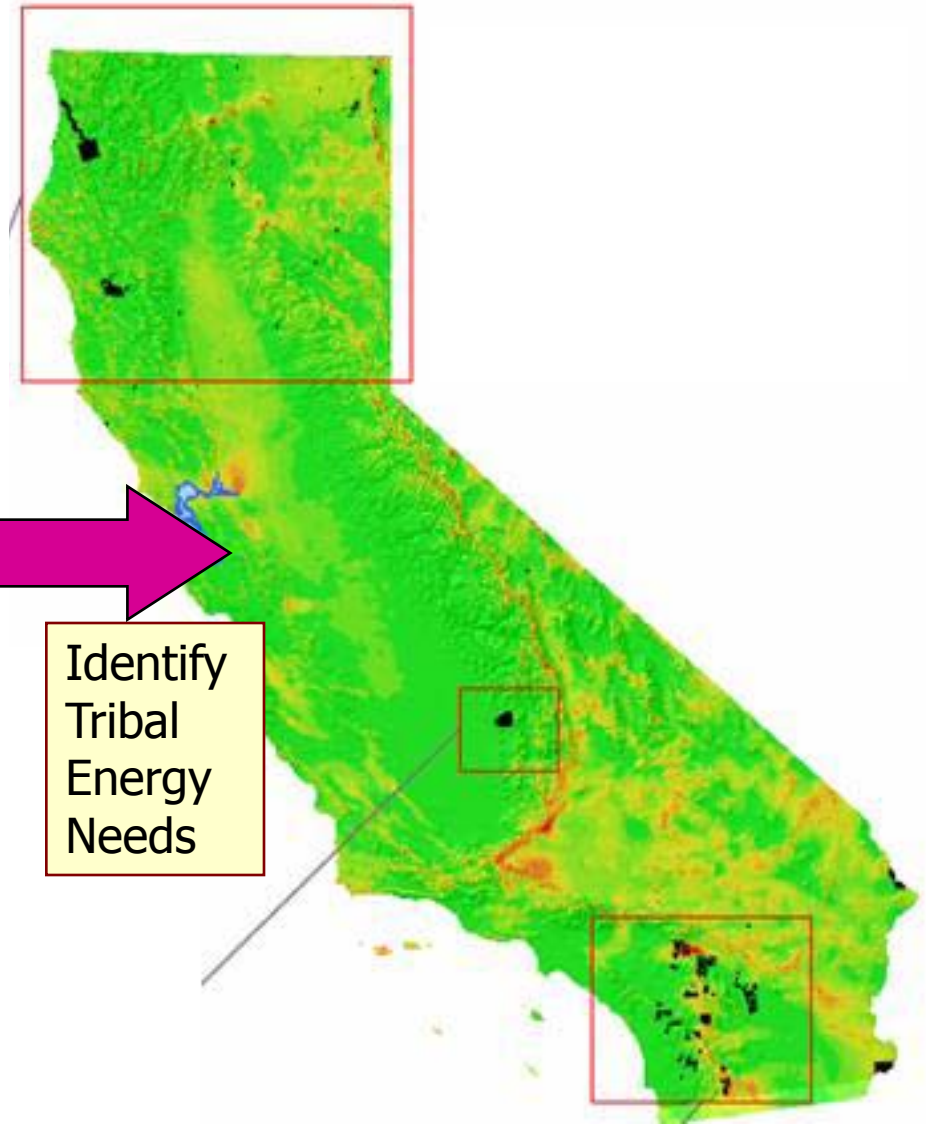


Meeting Common Needs



Identify State Energy Needs

Identify Tribal Energy Needs



November 27, 2003

Points to Share: Finding A Common Interest

- Common forum to communicate very complex issues
  - Involve all interested stakeholders in the big picture planning and analysis process (takes multi-disciplines to maximize broad resource base)
  - Help communicate and educate on the “Cans” and “Cannots” sticking with the facts – busting myths and rumors can take a long time
  - Educate the next generation
- Leveraging lessons learned from others but need to temper and tailor to ones OWN market, regulatory and infrastructure environment
- Remained technology neutral and assess a portfolio of resources
  - Understand cost-benefit tradeoffs but assess needs for the benefit of the entire state
  - Have options
- Ensured system reliability and sustainability for the long haul !! !!!
  - Band-aid fixes are costing more money and make the system less flexible to change and sometimes more vulnerable
  - Re-evaluate and re-assess timely to stay ahead of transforming technology and demand
- Stay informed – BE PART OF THE SOLUTION

Additional Information

California Energy Commission Web Sites:

- Renewable Energy Program www.energy.ca.gov/renewables/index.html
  - Information on consumer education, emerging and existing renewable, new renewable & incentive programs http://www.energy.ca.gov/renewables/consumer_education/index.html
  - Call Center e-mail: Renewable@energy.state.ca.us
  - Call Center Phone: (800) 555-7794
  - California's Consumer Energy Center www.consumerenergycenter.org
  - Renewable Energy Program's *Overall Program Guidebook* and *Renewables Portfolio Standard Eligibility Guidebook* located at: http://www.energy.ca.gov/renewables/documents/index.html
  - The Western Renewable Energy Generation Information System (WREGIS), a renewable energy registry and tracking system for the Western Interconnection http://www.energy.ca.gov/portfolio/wregis/index.html

RENEWABLE ENERGY PROGRAM
CALIFORNIA ENERGY COMMISSION

- Public Interest Energy Research (PIER) www.energy.ca.gov/pier/
  - Commission Cartography Office for details about ordering printed versions of maps by calling 916-654-3902, http://www.energy.ca.gov/maps/wind.html
  - Technology and resource reports: various links on Commission website for wind, geothermal, solar (CSP & PV), hydro and biomass

California Public Utilities Commission Web Site:

- Renewables Portfolio Standard
  www.cpuc.ca.gov/PUC/energy/electric/renewableenergy/index.htm

Thank you

Questions/Comments??

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